MODELLING DEPRESSIONAL STORAGE AND PONDING IN A CANADIAN PRAIRIE LANDSCAPE

VOLUME 2

FIGURES, TABLES & APPENDICES

by

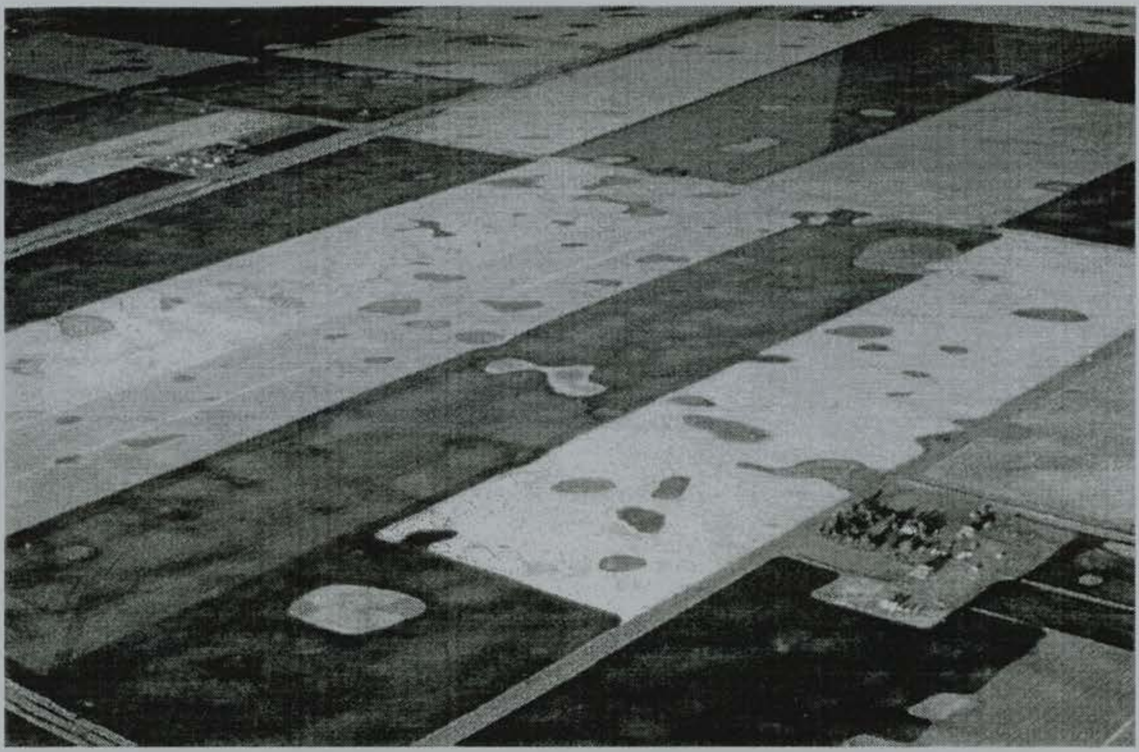
ROBERT A. MacMILLAN

PhD.

UNIVERSITY OF EDINBURGH

AUTUMN, 1994

FIGURES



(a) Disrupted cultivation pattern in a depressional "prairie pothole" landscape.

(b) Uniform cultivation patterns in a well drained agricultural landscape.

Figure 1.1 Oblique aerial views illustrating impediments to efficient cultivation in an agricultural landscape characterised by numerous ephemeral ponds (a) versus a uniformly well drained landscape (b).

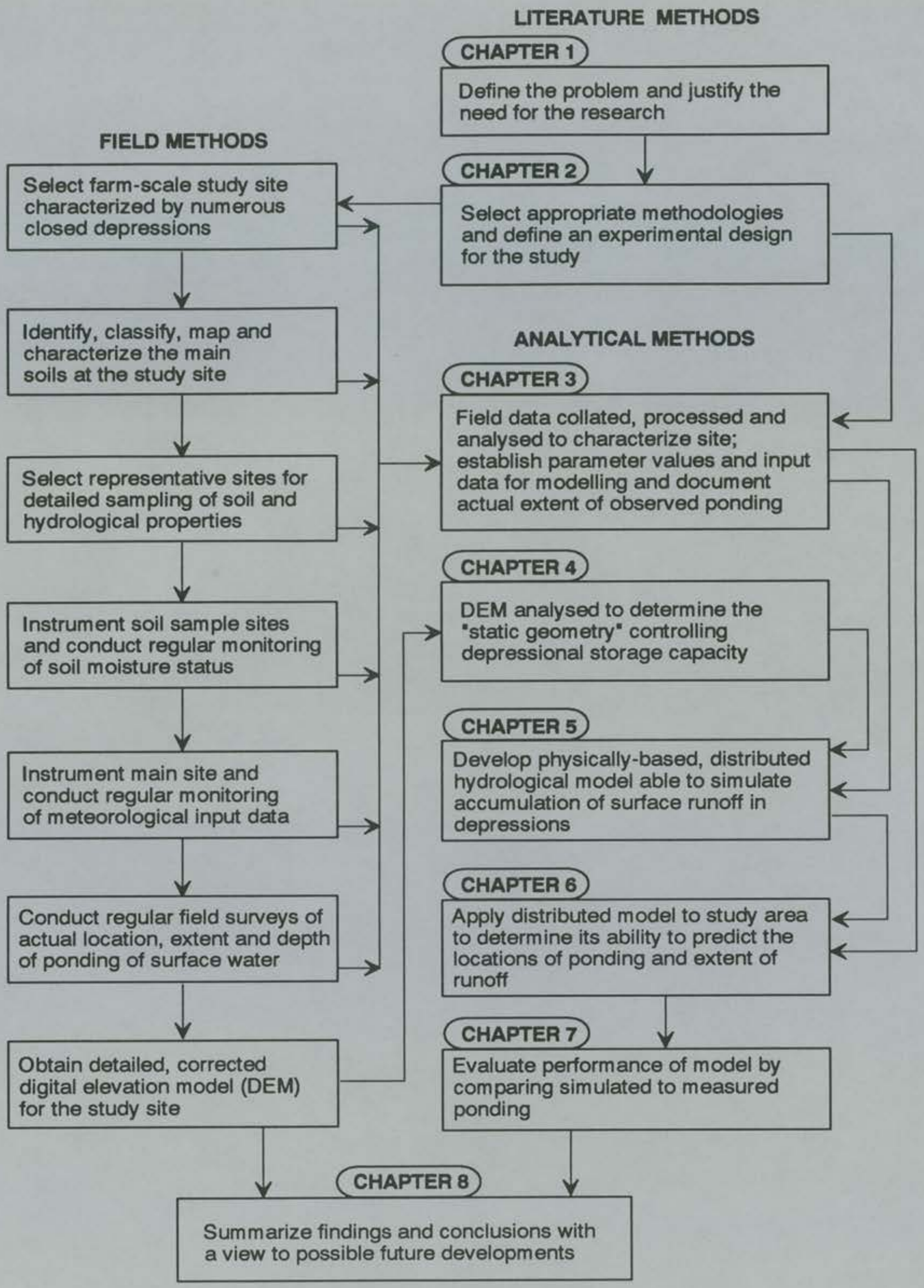


Figure 1.2 Experimental design: flowchart of research methods and organisation of thesis.

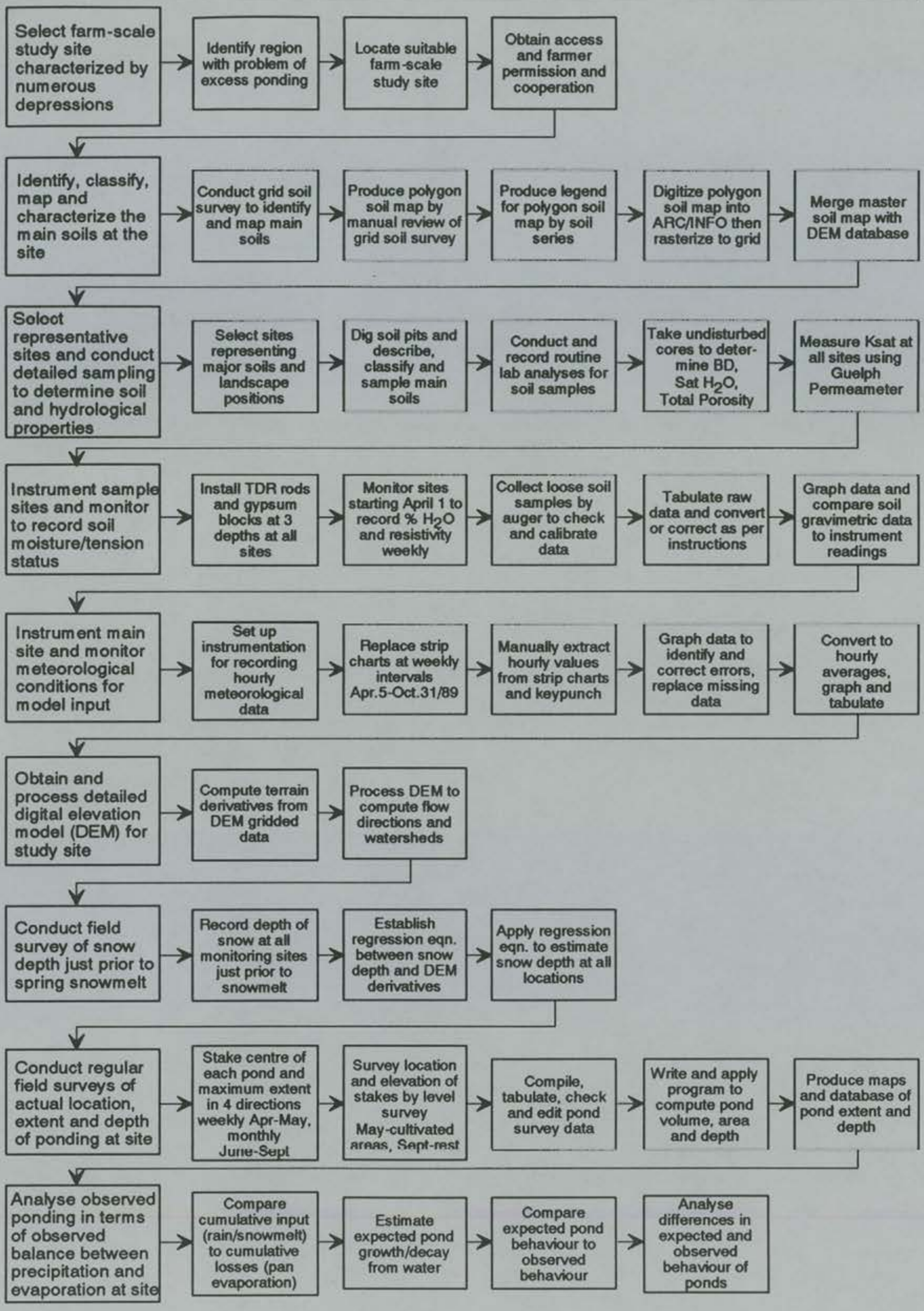


Figure 3.1 Experimental design - field study: procedures followed in selecting, characterising, instrumenting and monitoring study site.

(a) Detailed profile descriptions were conducted for the soil survey and site characterisation.

(b) A Gittings hydraulic corer was used to take undisturbed core samples and to assist in the installation of soil moisture monitoring instruments.

Figure 3.2 Field characterisation by detailed soil survey (a) and core sampling (b)

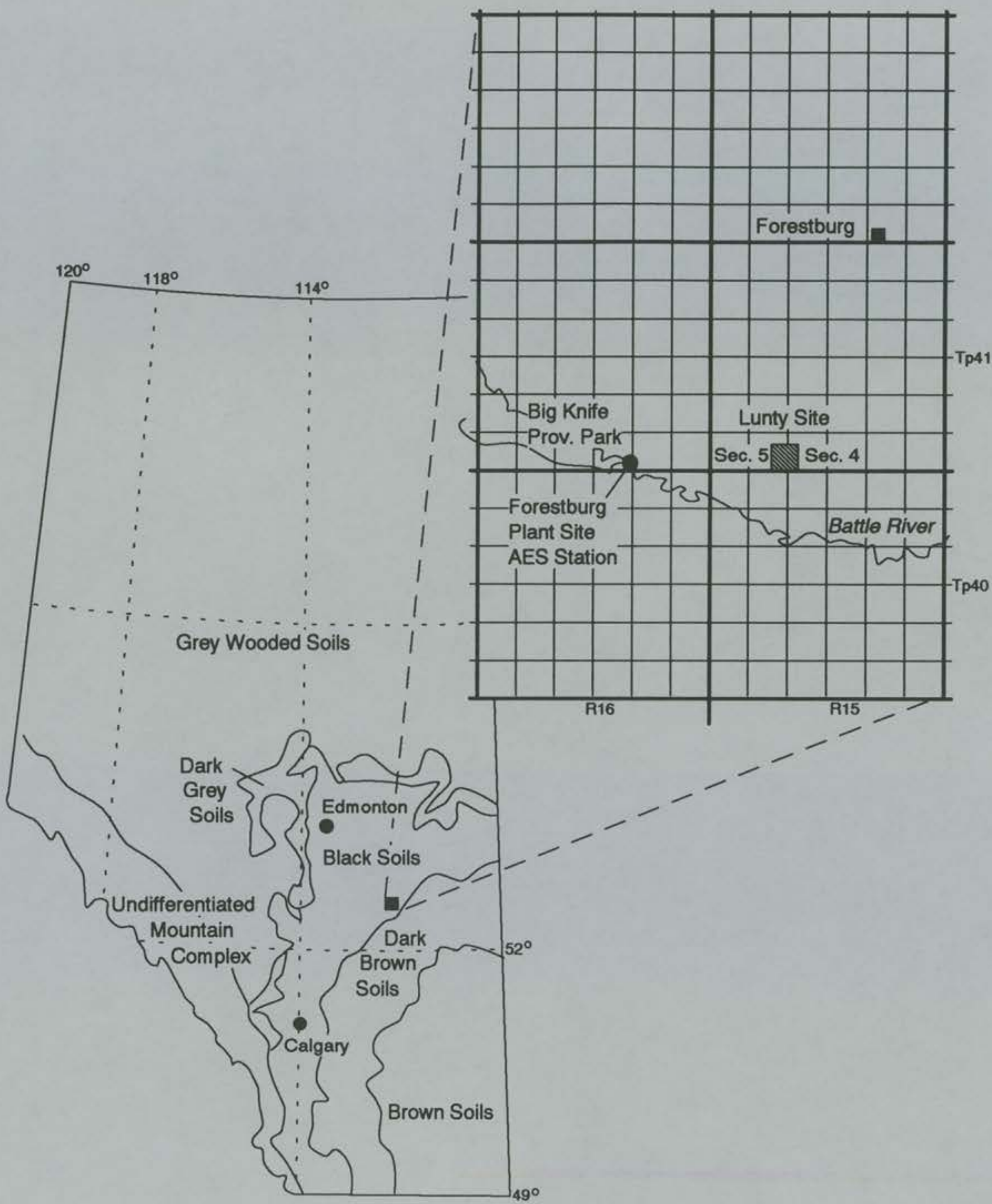
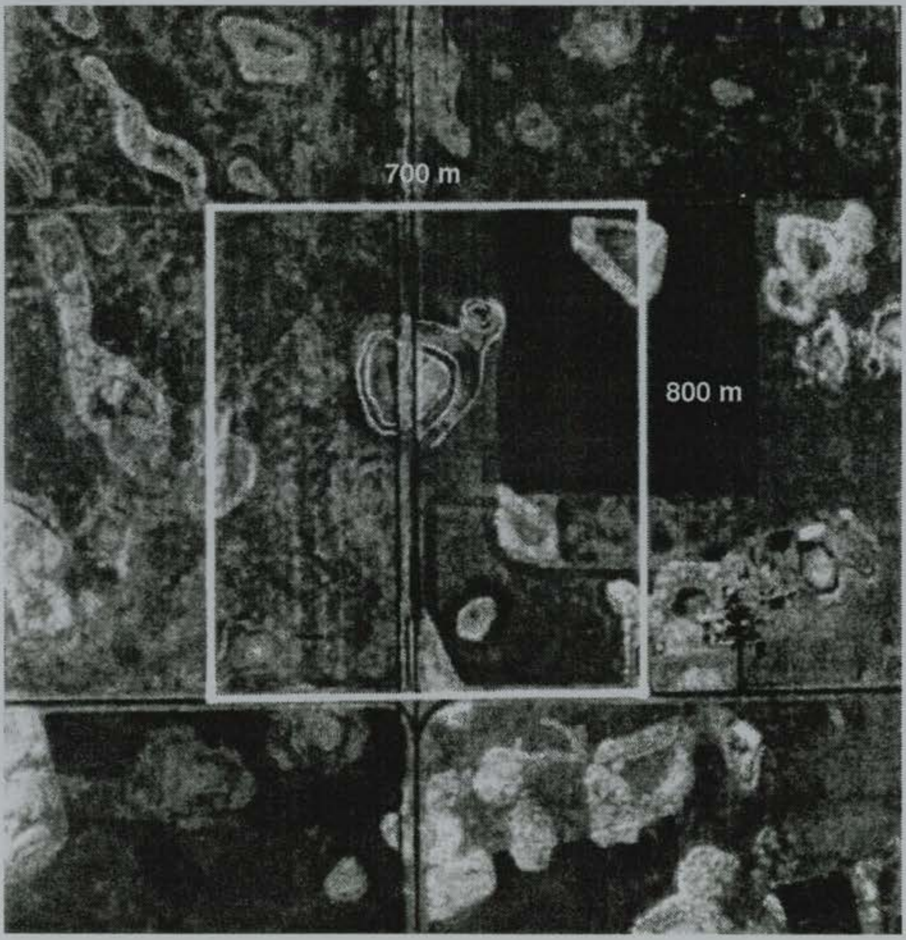


Figure 3.3 Location of the Lunty study site.

(a) Oblique aerial view of the Lunty site looking from NE to SW.



(b) Vertical aerial view of the Lunty site with boundaries indicated.

Figure 3.4 Oblique (a) and vertical (b) aerial views of the Lunty study site.

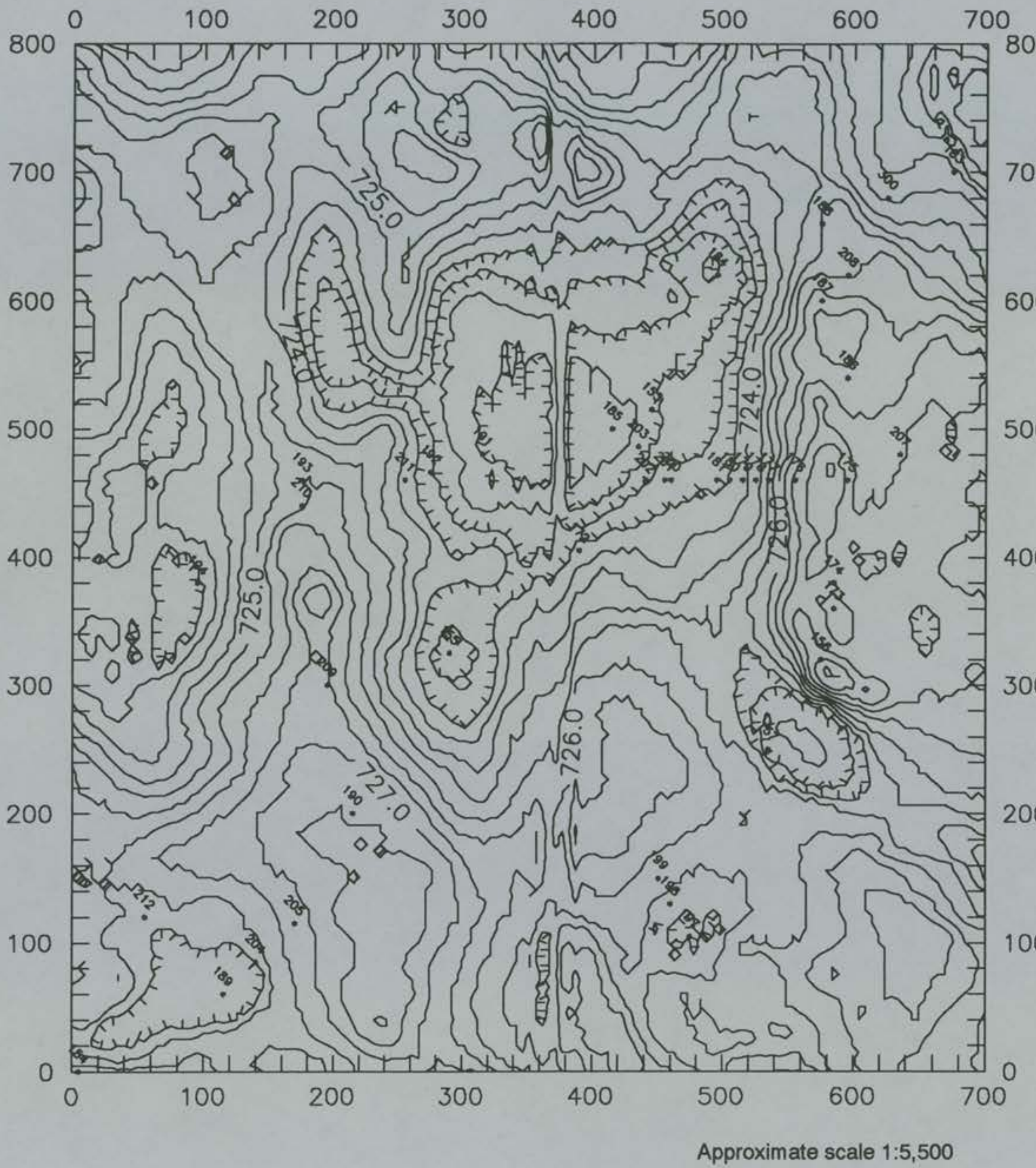


Figure 3.5 Contour map of the Lunty site topography.

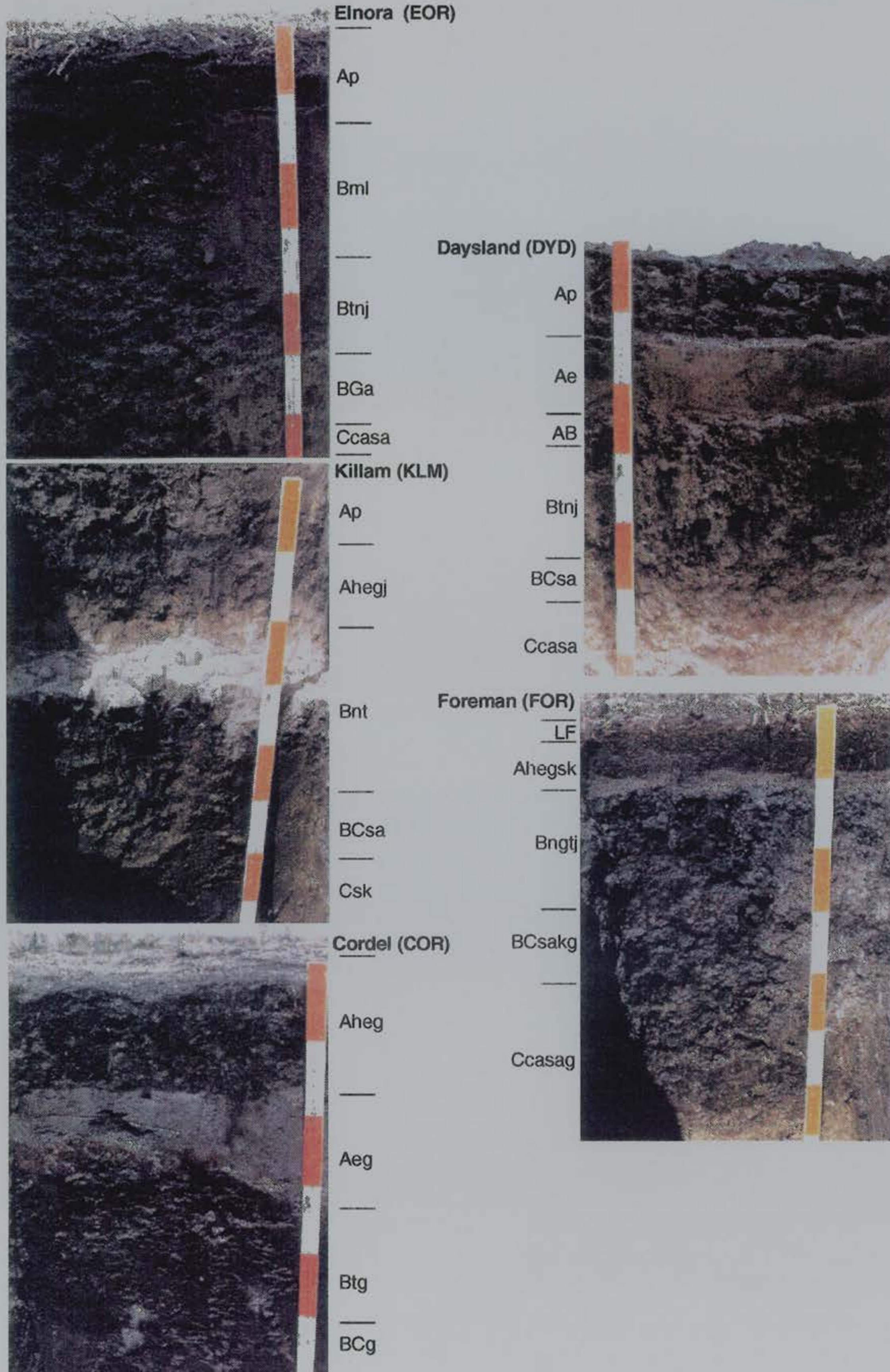


Figure 3.6 Illustration of the main Soil Series recognised at the Lunty site.

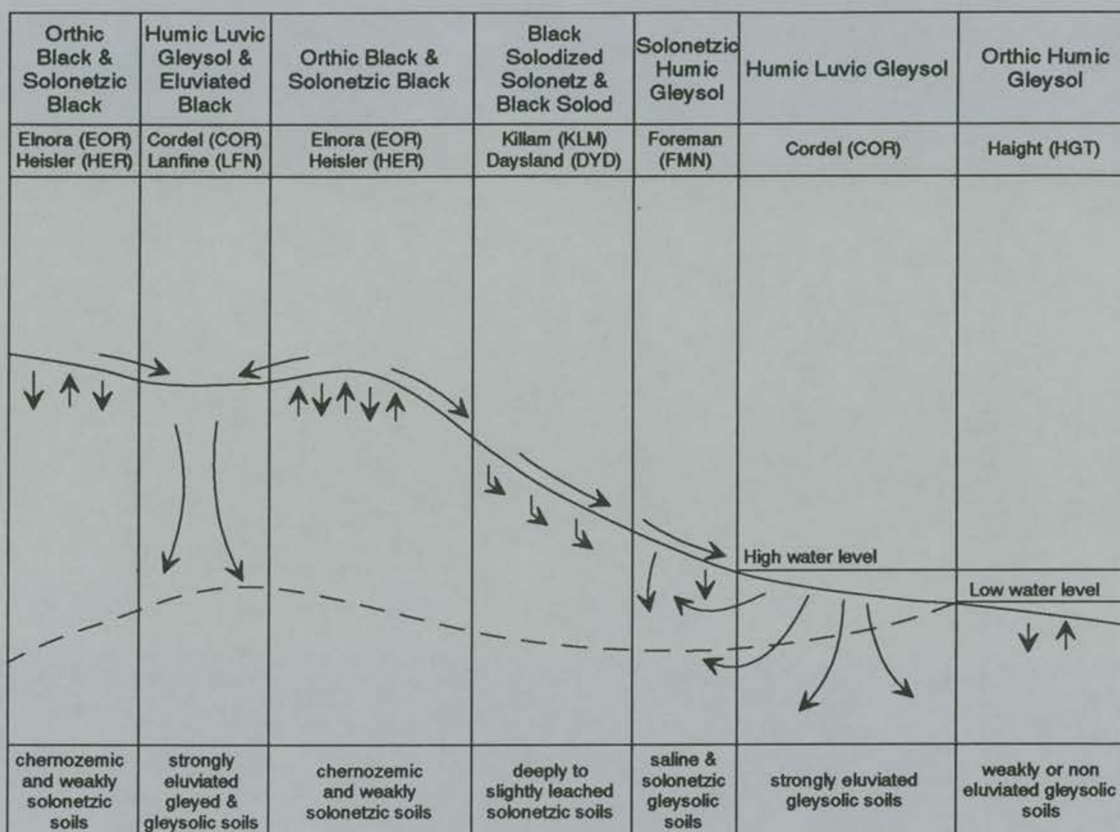
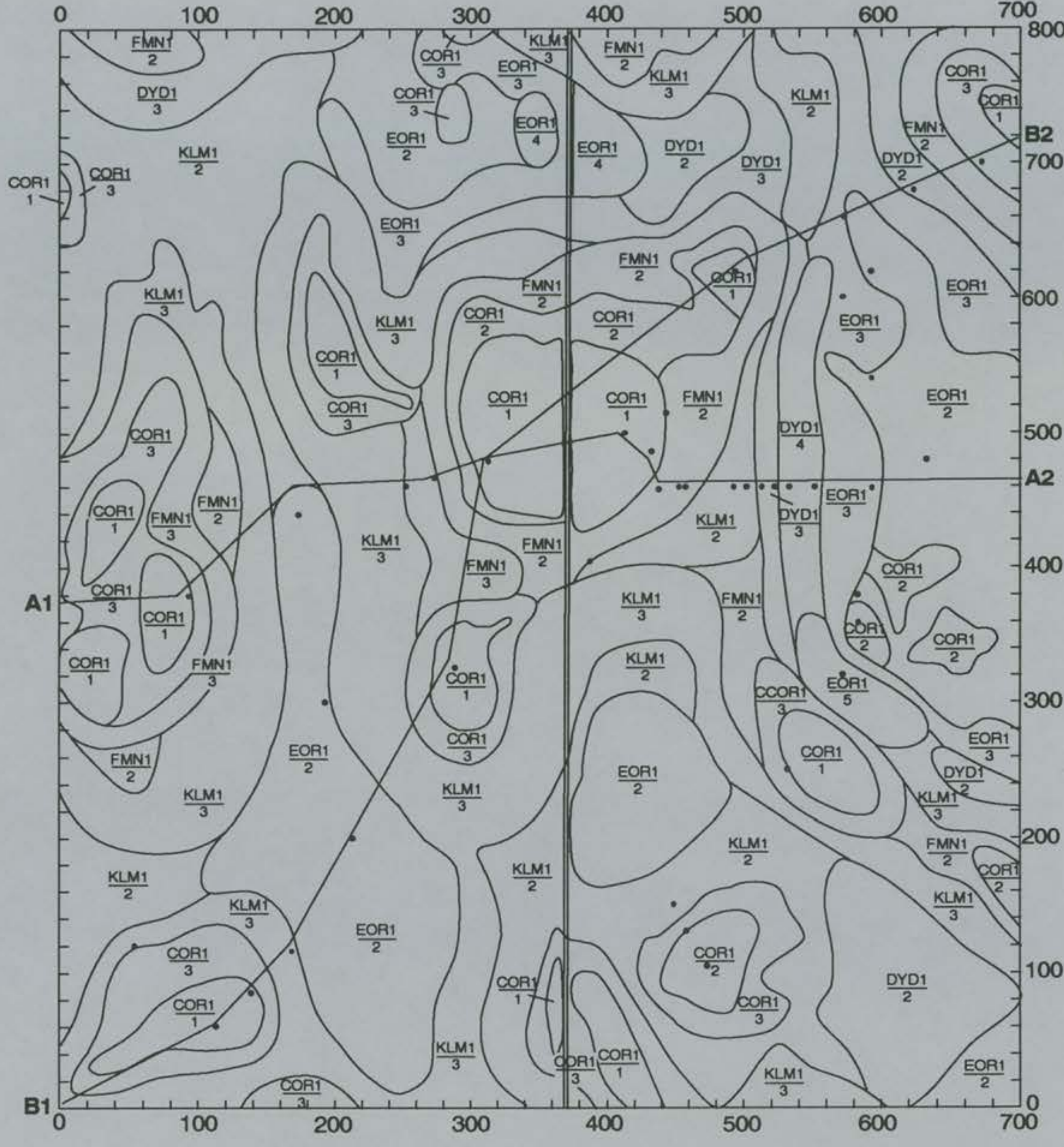


Figure 3.7 Illustration of the conceptual soil-landscape model developed for the Lunty site.



Approximate scale 1:5,500

Figure 3.8 Choropleth soil map of the Lunty site showing the locations of cross-sectional transects.

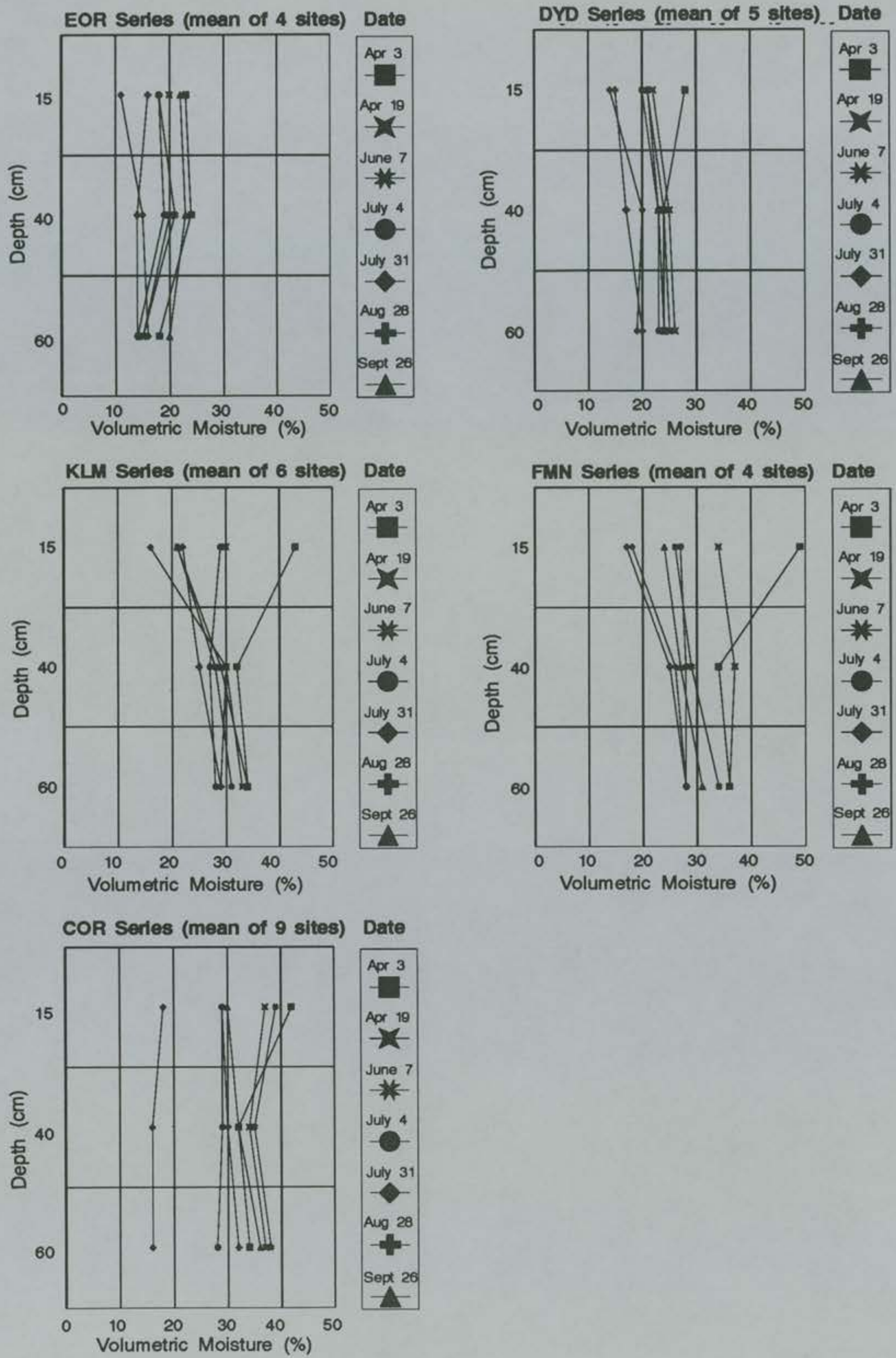


Figure 3.9 Mean soil profile volumetric moisture for the three monitoring depths for the period April - October for the main Soil Series at the Lunty site.

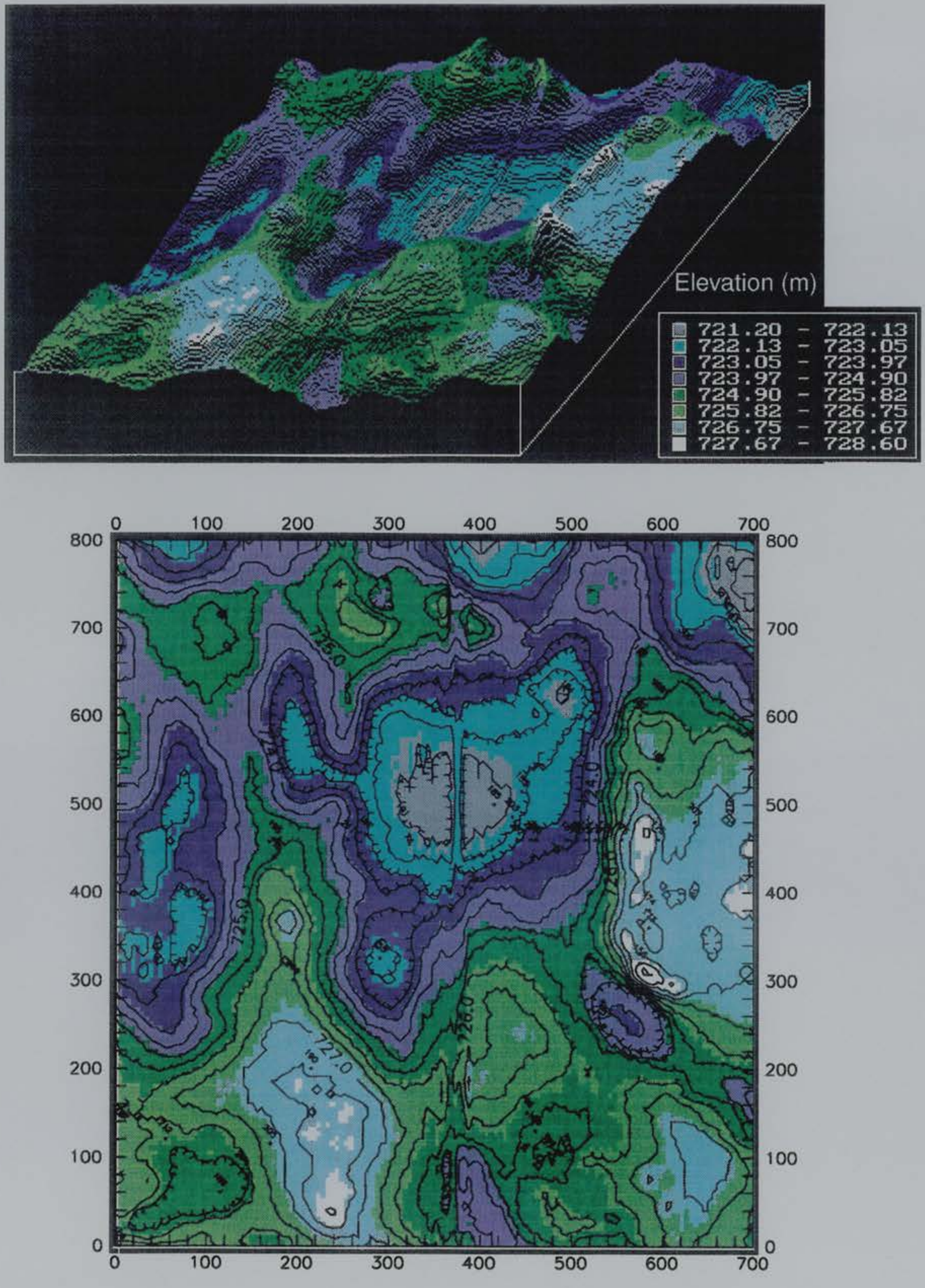


Figure 3.10 Digital elevation model (DEM) of the Lunty site displayed as a draped three dimensional perspective view (top) and a grid map (bottom).

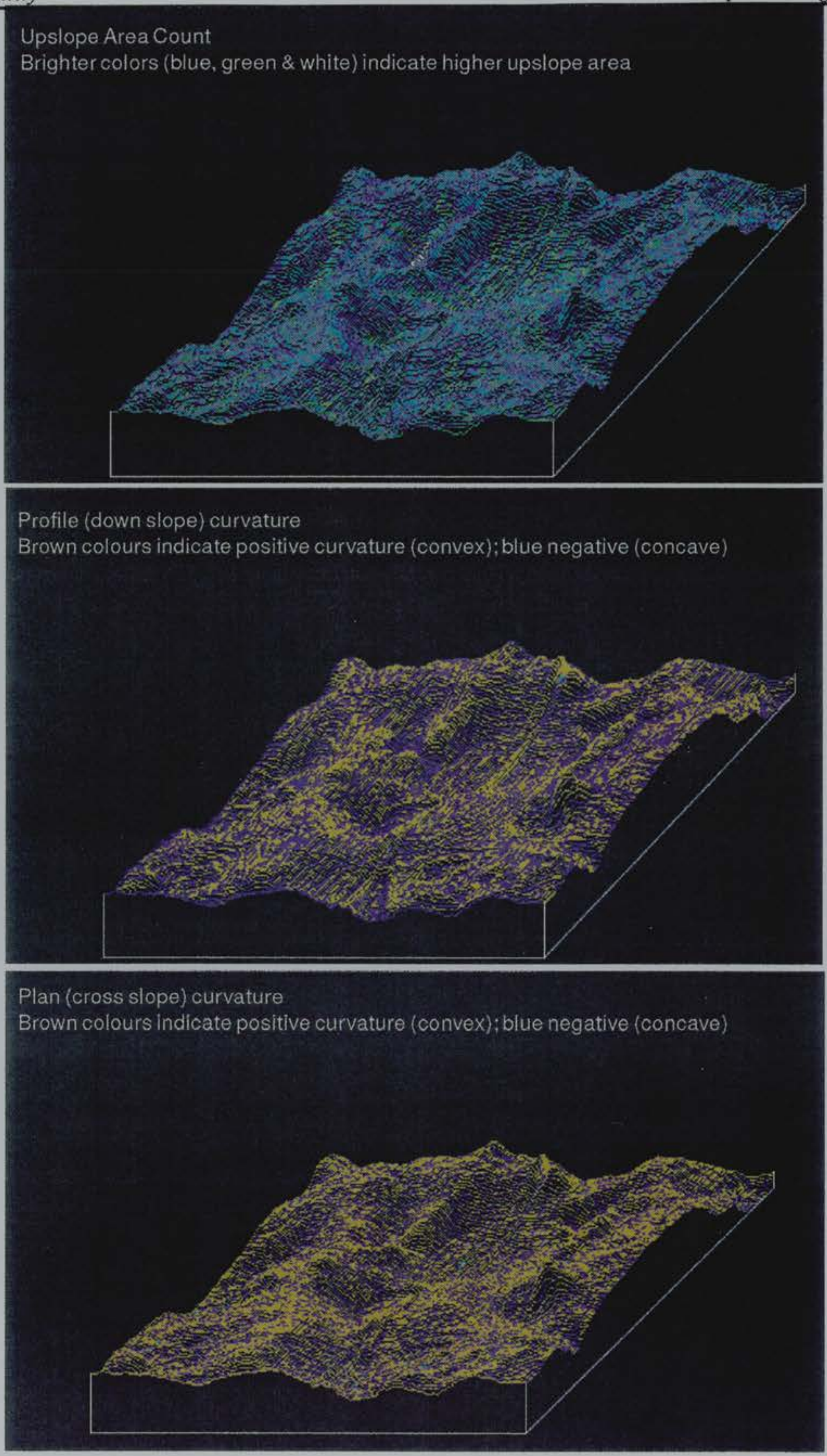


Figure 3.11 Terrain derivatives upslope area (top), profile curvature (middle) and plan curvature (bottom) displayed draped over the Lunty site DEM.

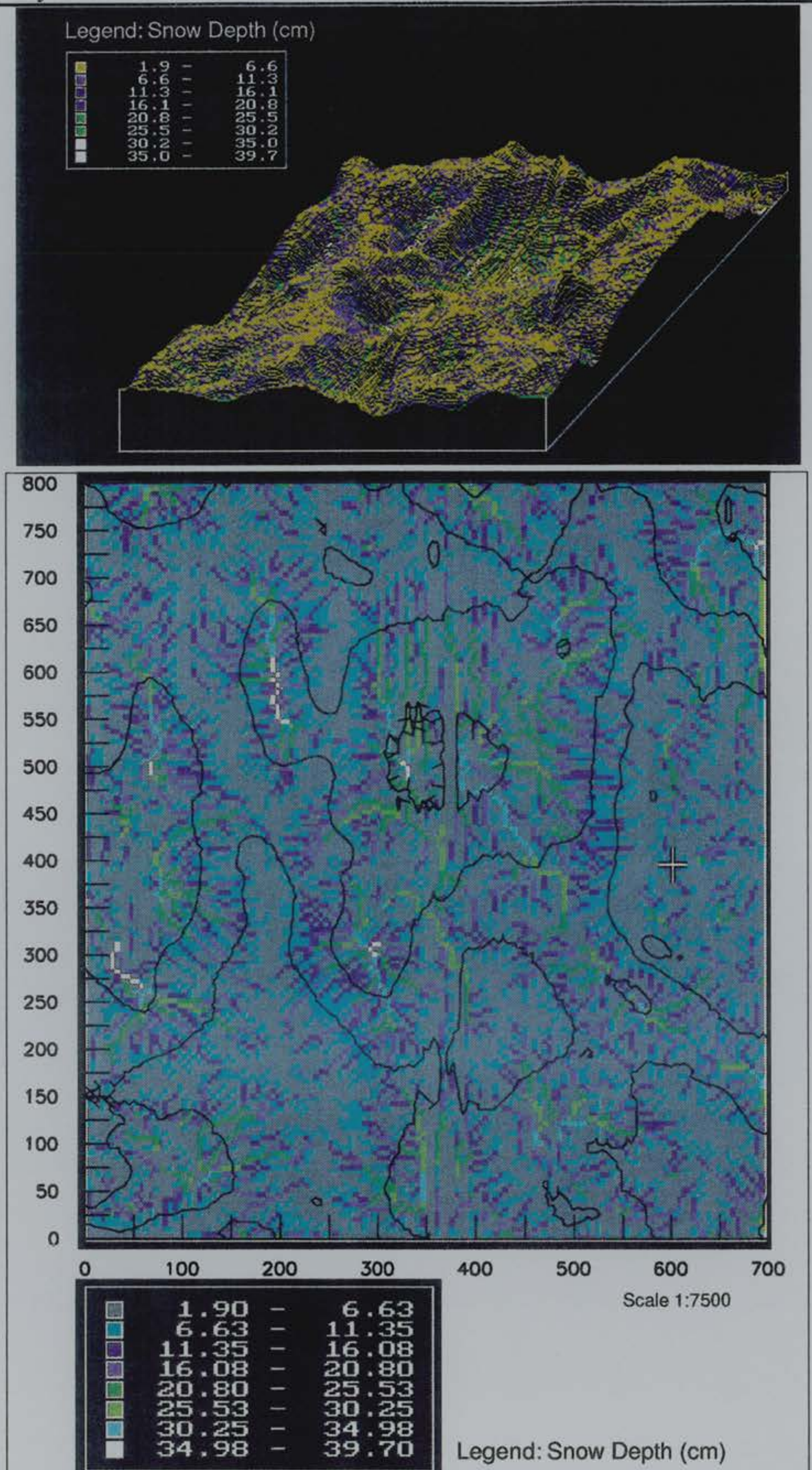
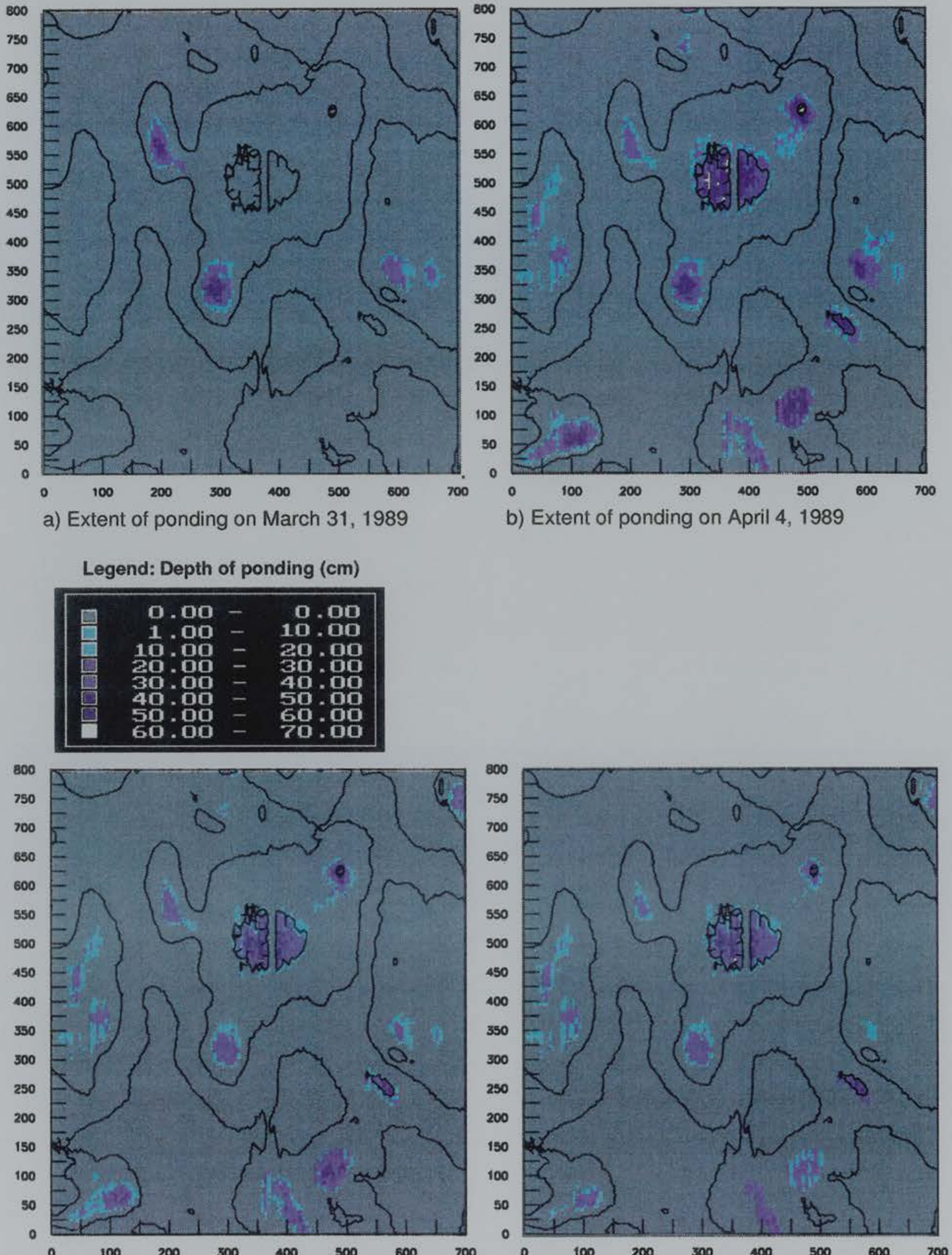


Figure 3.12 Estimated depth of snow (cm) displayed draped over topography (top) and as a 2 dimensional grid map (bottom).



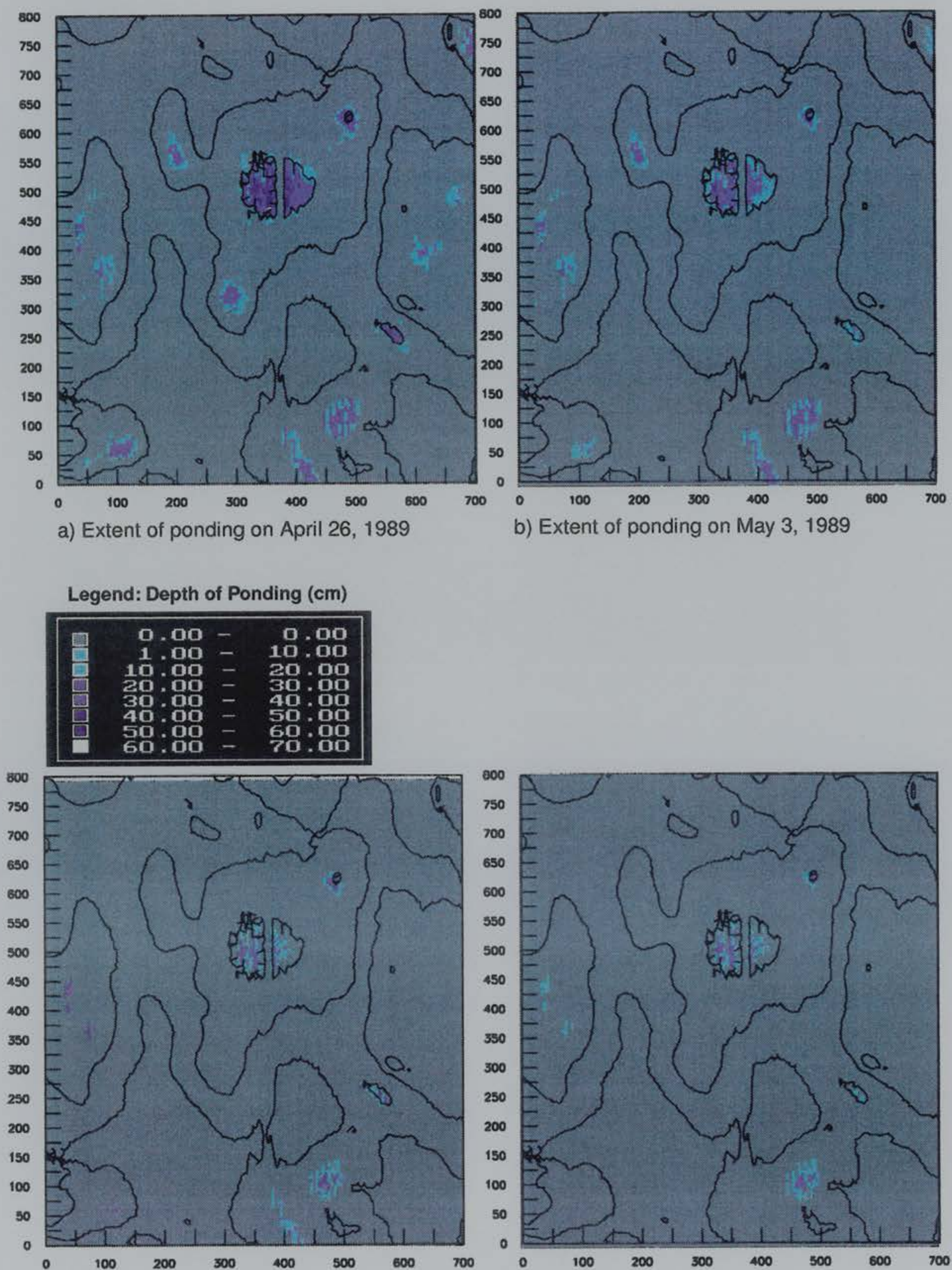
a) Extent of ponding on March 31, 1989

b) Extent of ponding on April 4, 1989

c) Extent of ponding on April 12, 1989

d) Extent of ponding on April 19, 1989

Figure 3.13 Grid maps illustrating the location, extent and depth of ponding as determined by field surveys on March 31 and April 4, 12, & 19, 1989.



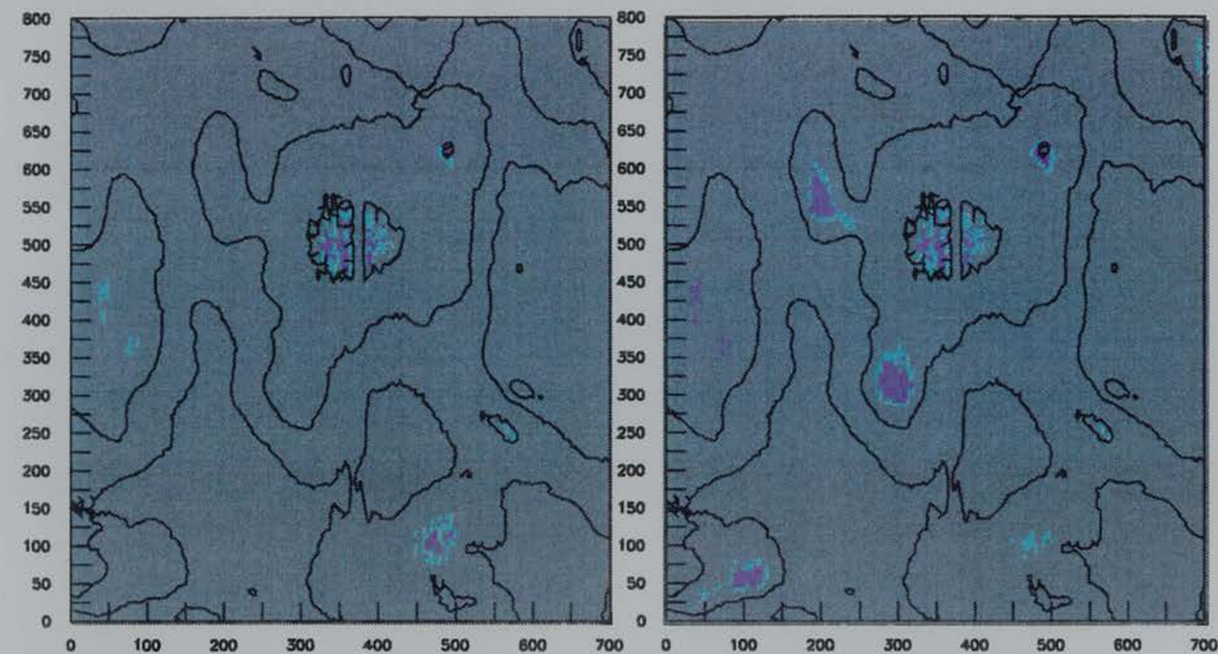
a) Extent of ponding on April 26, 1989

b) Extent of ponding on May 3, 1989

c) Extent of ponding on May 10, 1989

d) Extent of ponding on May 17, 1989

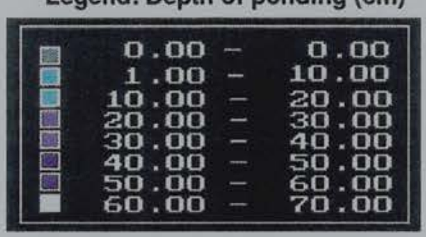
Figure 3.14 Grid maps illustrating the location, extent and depth of ponding as determined by field surveys on April 26 and May 3, 10, & 17, 1989.

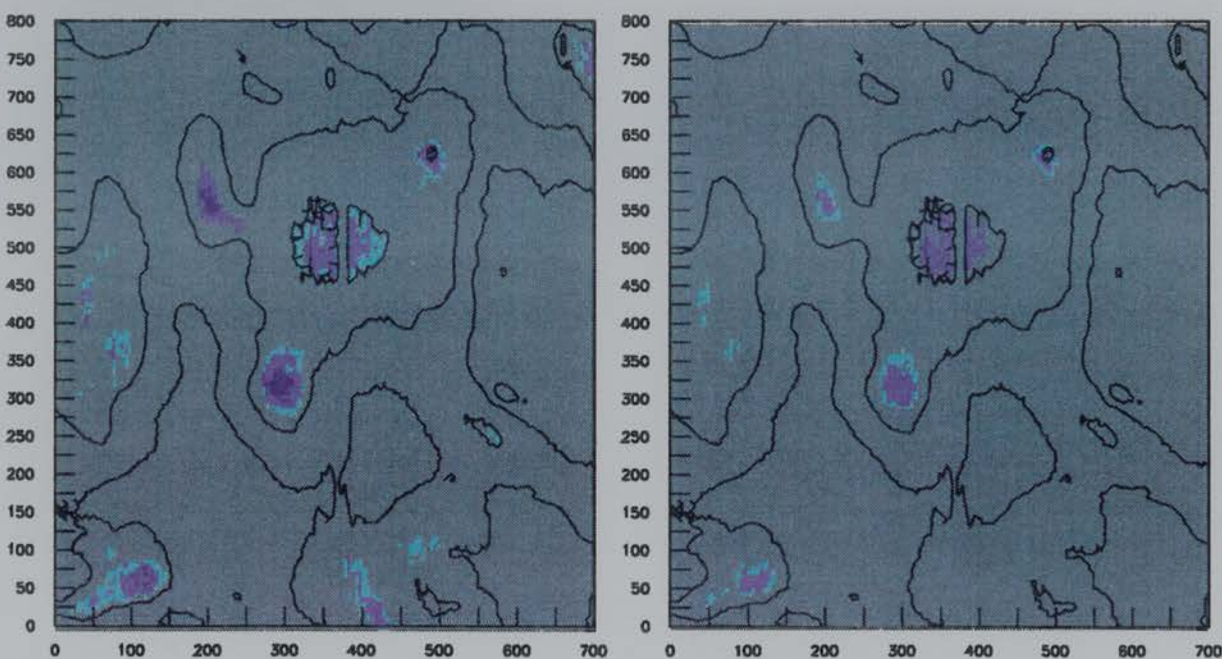


a) Extent of ponding on May 24, 1989

b) Extent of ponding on July 4, 1989

Legend: Depth of ponding (cm)

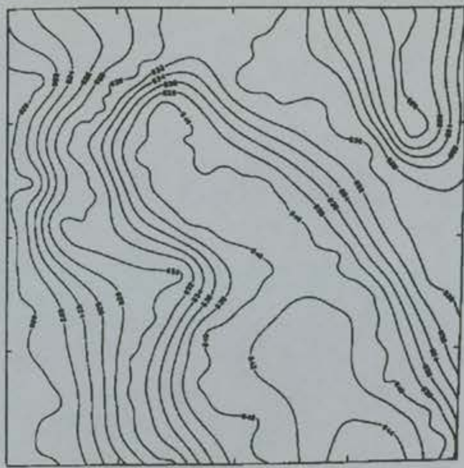




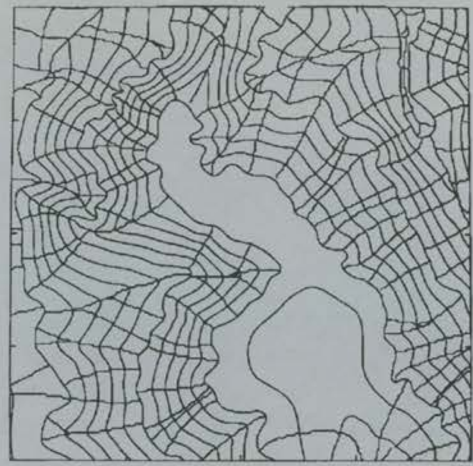
c) Extent of ponding on July 11, 1989

d) Extent of ponding on July25, 1989

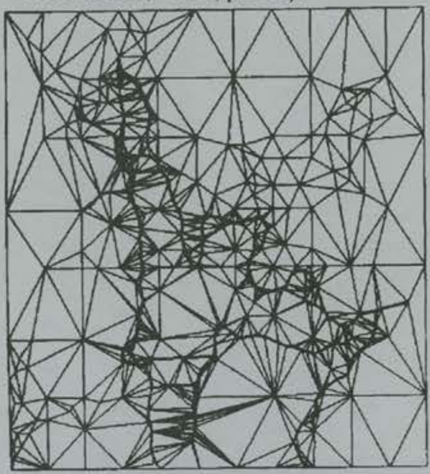
Figure 3.15 Grid maps illustrating the location, extent and depth of ponding as determined by field surveys on May 24 and July 4, 11, & 25, 1989.



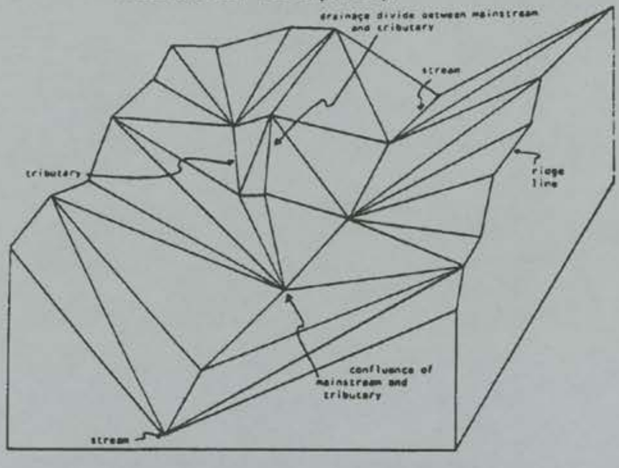
a) Traditional isopleth contour lines (from Hutchinson, 1988, p.129).



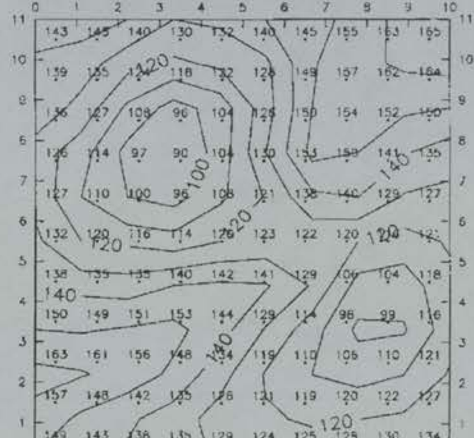
b) Stream lines, ridge lines and slope facets (from Hutchinson, 1988, p.130).



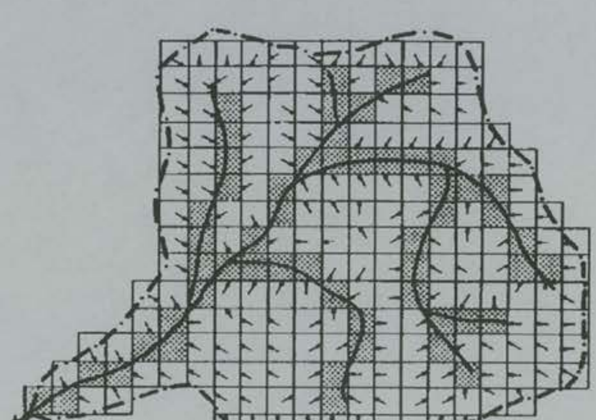
c) Triangular Irregular Networks (TINs) (from Chen, 1988, p.790).



d) Stream lines, ridge lines and slope facets (from Heil, 1980, p.134).

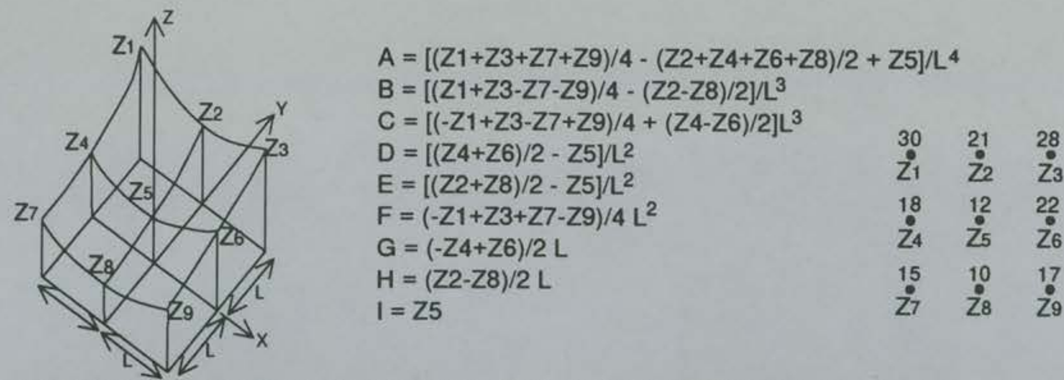


e) Regular gridded elevation data (DEMS) (hypothetical data).

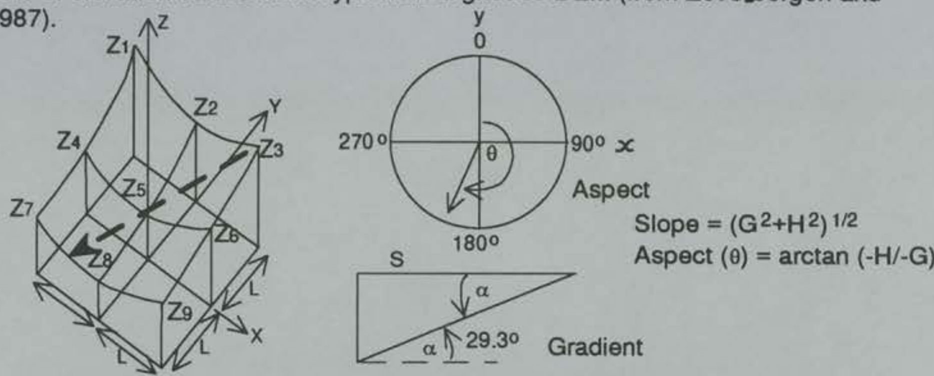


f) Local direction of flow, stream lines and catchment area (from Novotny, 1986, p.135).

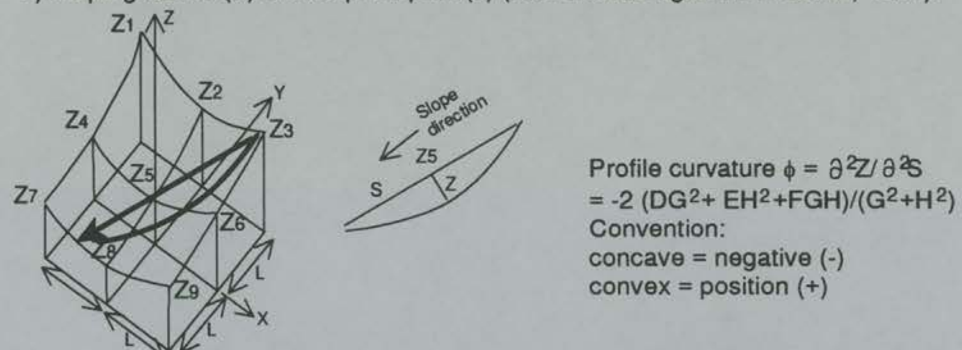
Figure 4.1 Principal types of data structures used to represent topography for automated extraction of geomorphological and hydrological features.



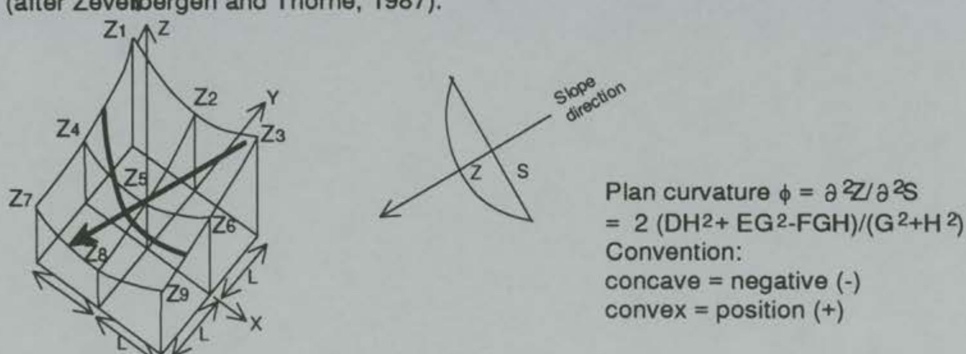
a) 3 x 3 window of elevation values from hypothetical gridded DEM (from Zevenbergen and Thorne, 1987).



b) Slope gradient (α) and slope aspect (θ) (after Zevenbergen and Thorne, 1987).

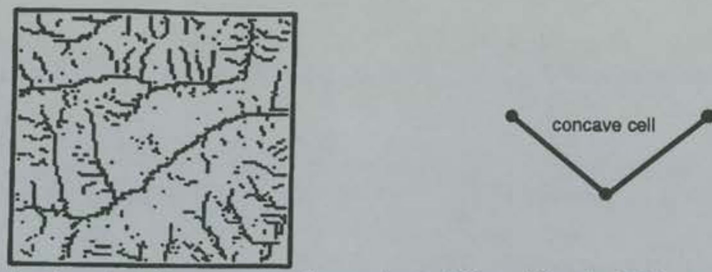


c) Profile or downslope curvature (rate of change of slope in the downslope direction) (after Zevenbergen and Thorne, 1987).

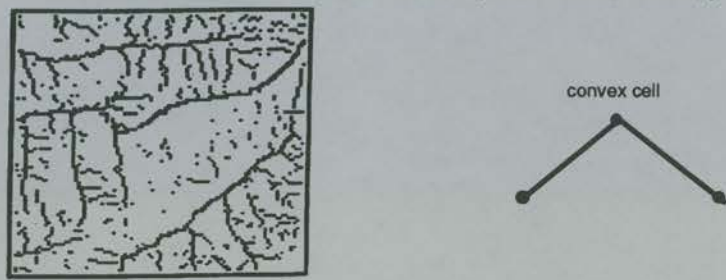


d) Plan or cross-slope curvature (rate of change of slope in the cross-slope direction (after Zevenbergen and Thorne, 1987).

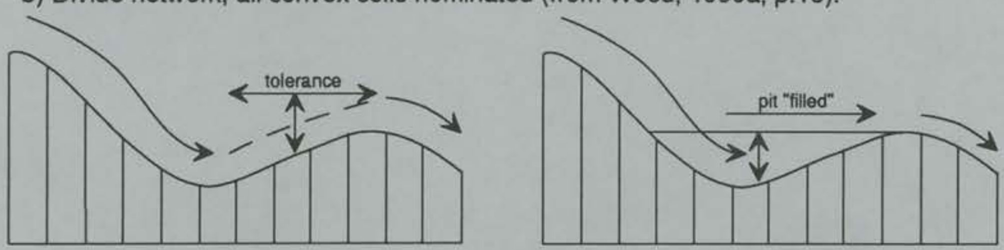
Figure 4.2 Extraction of local measures of surface form (terrain derivatives) from gridded DEMs. Letters A-I are intermediate solutions of the quadratic.



a) Channel networks, all concave cells nominated (from Wood, 1990a, p.13).

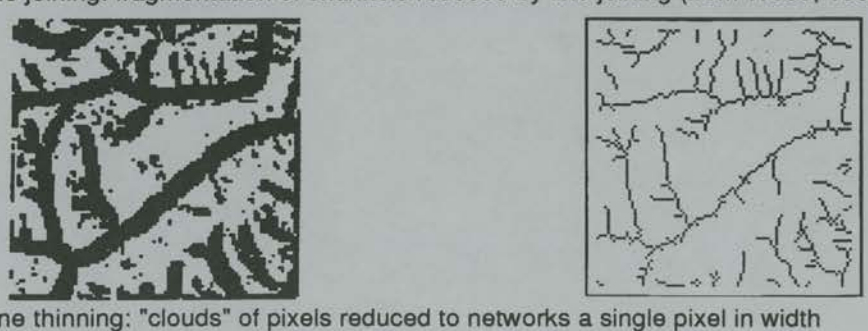


b) Divide network, all convex cells nominated (from Wood, 1990a, p.13).



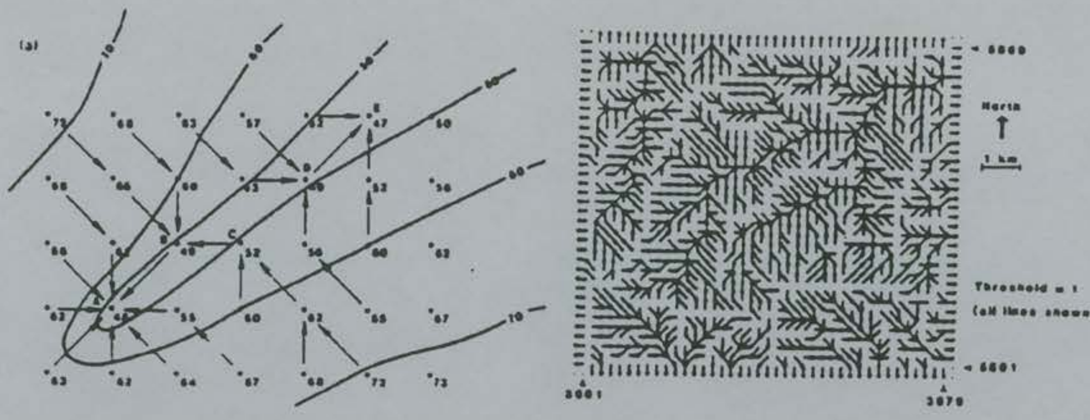
c) Techniques for line joining: "jumping gaps" of specified tolerance or "filling pits" (after Wood, 1990b).

d) Line joining: fragmentation of channels reduced by line joining (from Wood, 1990b, p.6.).

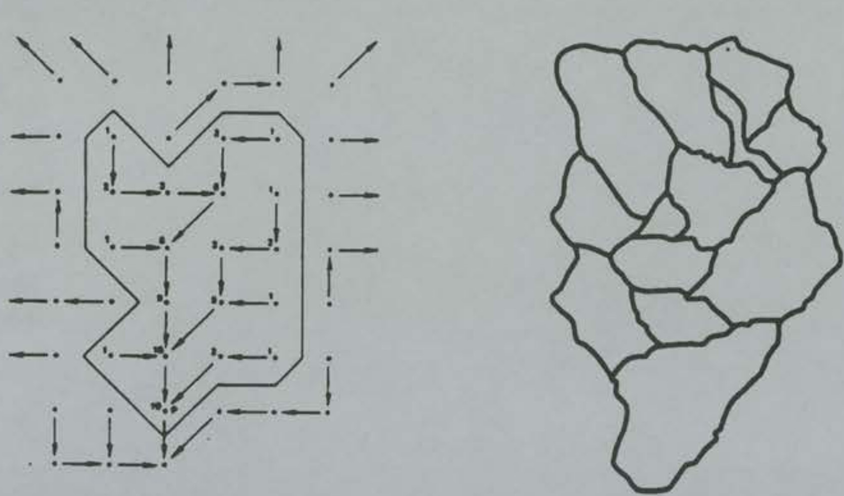


e) Line thinning: "clouds" of pixels reduced to networks a single pixel in width (from Wood, 1990b, pp.8 and 11).

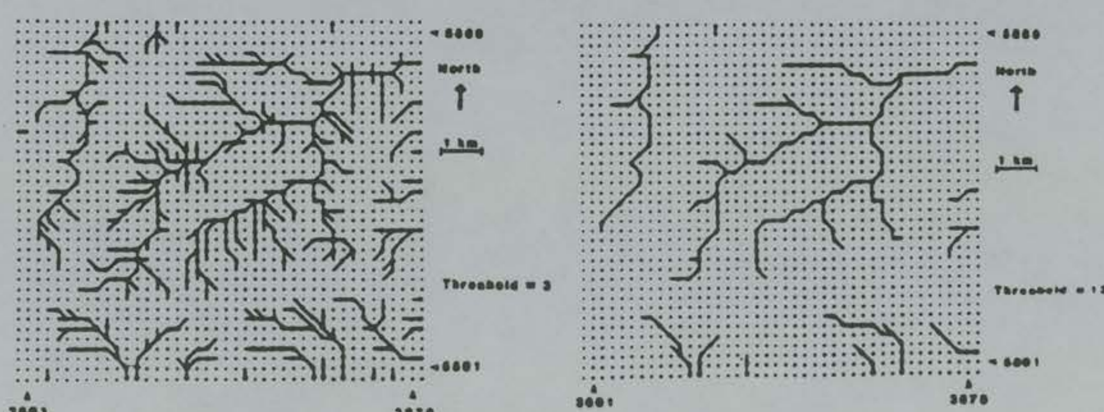
Figure 4.3 Extraction of hydrological features based on local surface form.



a) Determination of local direction of flow and flow paths (from Morris & Heerdegen, 1988, pp. 131 and 135).

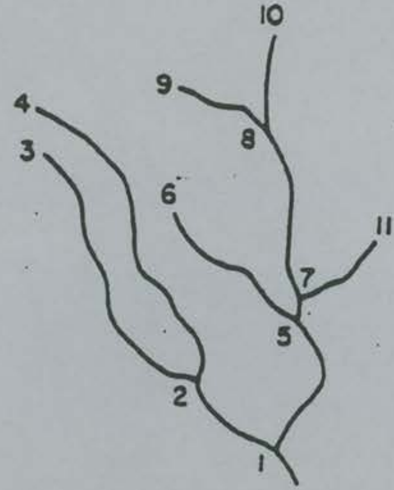


b) Determination of upslope area count and location of catchment boundaries (each cell contributes one unit of flow to its lowest downslope neighbour, all cells draining to the same outlet point belong to a single catchment) (from Morris and Heerdegen, 1988, p.138 and Band and Wood, 1988, p.30).



c) Determination of stream networks by thresholding of upslope area count (from Morris and Heerdegen, 1988, p.135).

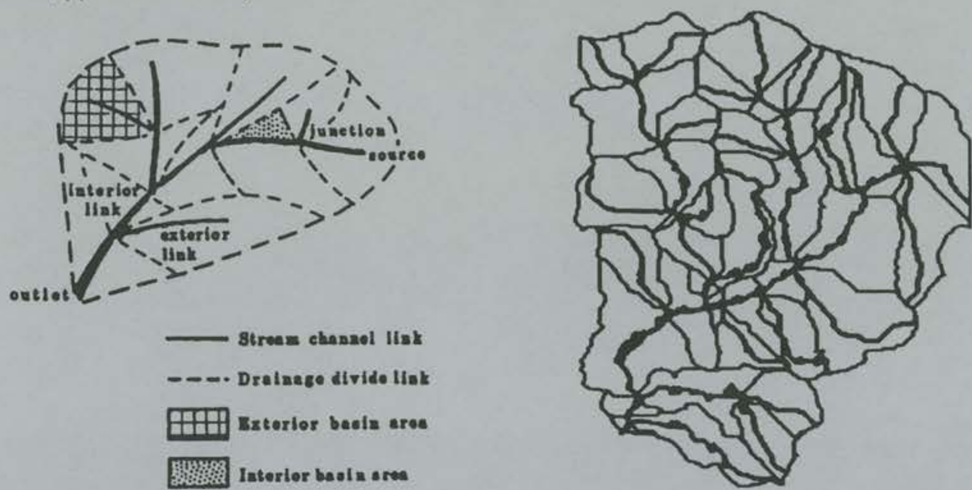
Figure 4.4 Extraction of hydrological features based on pixel to pixel connectivity.



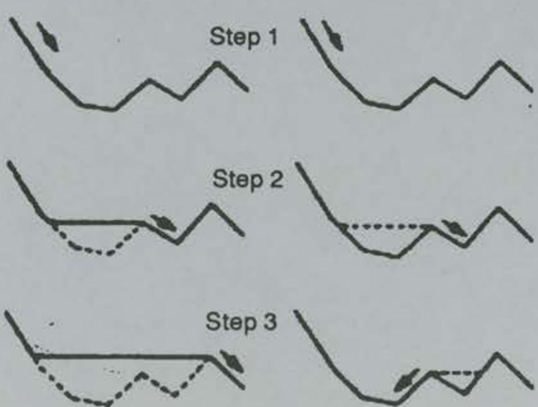
Topologic code and parallel data vectors for illustrated stream network (Table 1 in Band, 1989a).

Link number	Topologic code	Drainage area (sq.km.)	Local runoff (cubic metres)
1	2	0.02	20
2	2	1.18	1180
3	0	3.84	3840
4	0	2.45	2450
5	2	1.88	1880
6	0	1.63	1630
7	2	0.07	70
8	2	1.97	1970
9	0	0.94	940
10	0	0.97	970
11	0	0.90	900

a) Automated labelling of stream order and stream topology (connectivity) (from Band, 1989a, pp. 157 and 158).



b) Automated definition of fundamental terrain or hydrological units by intersection of channel and divide networks (from Band, 1986b, p.439; Band, 1989b, p.15).



The pour point table computed from the depressionless DEM and watershed data set. Parenthesized watershed numbers indicate the lowest, or tied for the lowest, pour point for the watershed. (Table 7 in Jenson and Dominique, 1987.)

Watershed	Pour Point		
Pair	Elevation	Line	Sample
0 - 1	737	2	4
(1) - (2)	733	4	5
1 - 4	785	4	9
1 - 3	797	4	10
(2) - (4)	733	5	6
(3) - 4	738	7	8
0 - (3)	738	7	8
0 - 2	786	4	1
0 - (4)	733	8	7
2 - 5	762	8	5
(4) - 5	733	8	7
0 - (5)	728	9	7

c) Identification and documentation of "pits" or depressions (from Yuan and Vanderpool, 1986, p.654; Jenson and Dominique, 1988, p.1599).

Figure 4.5 Automated extraction of higher order features of hydrological and ecological significance.

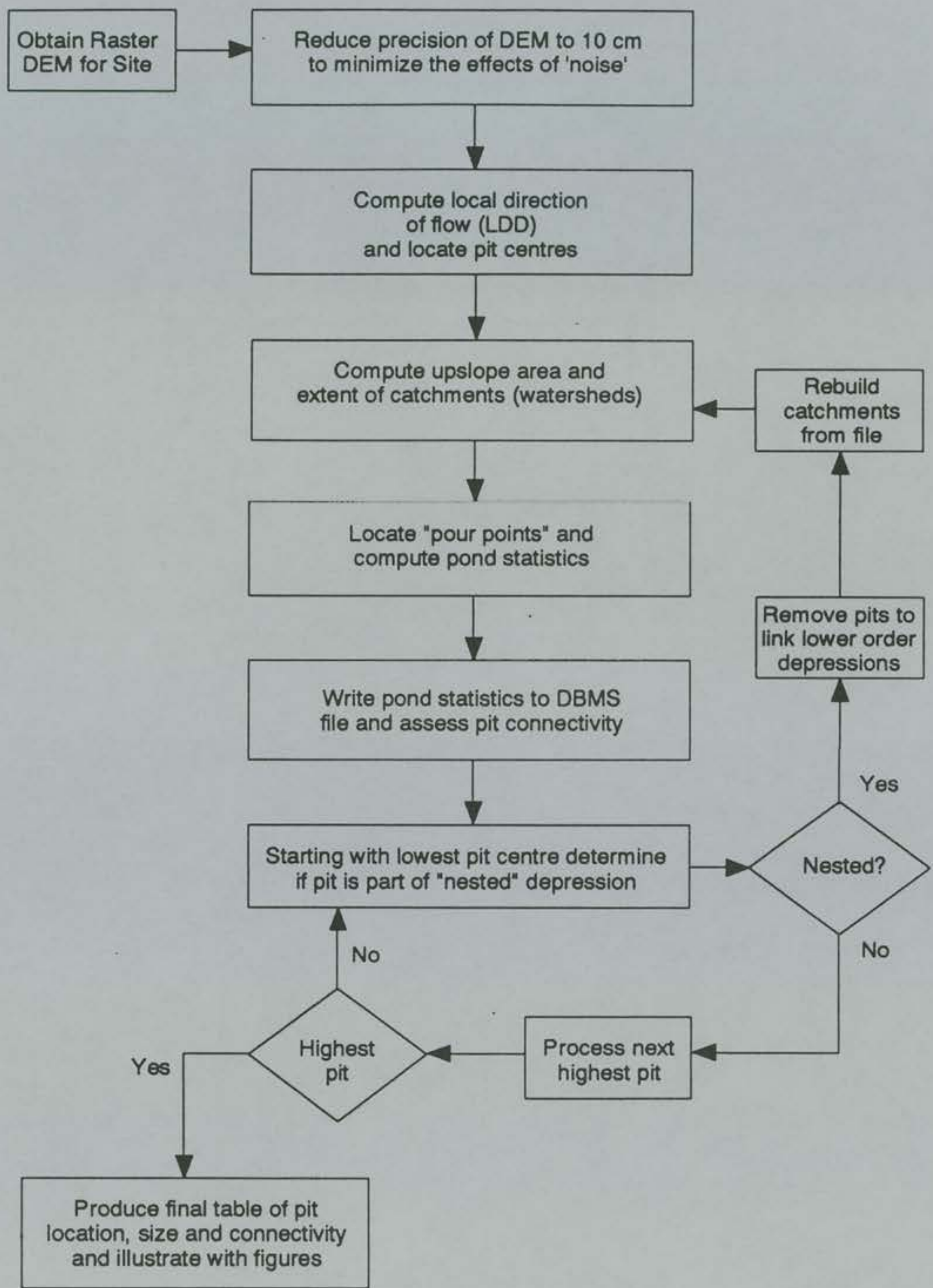
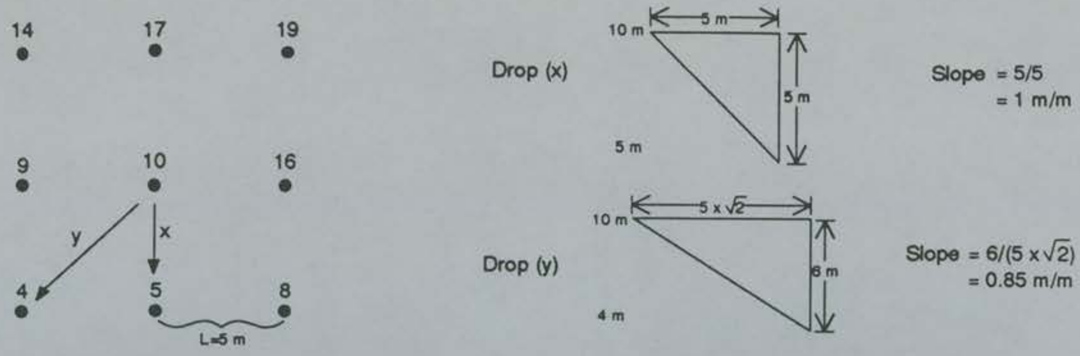
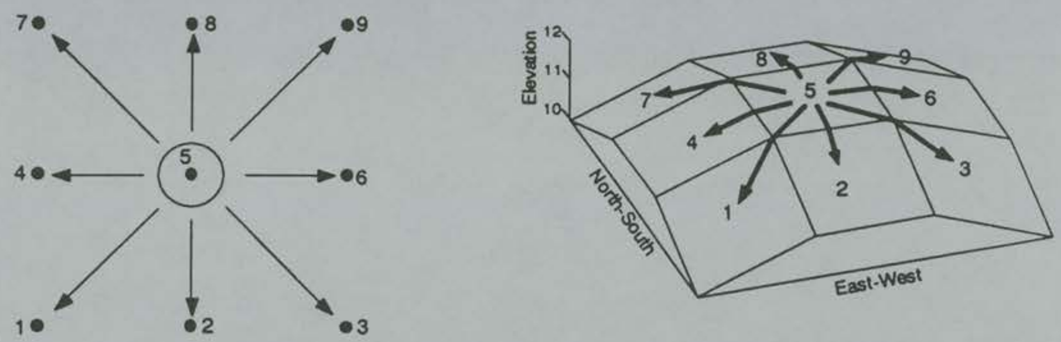


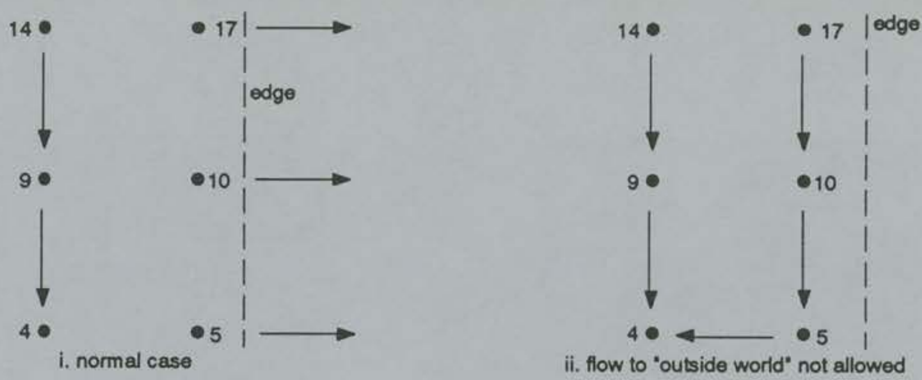
Figure 4.6 Experimental design for establishing the location and size of all depressions.



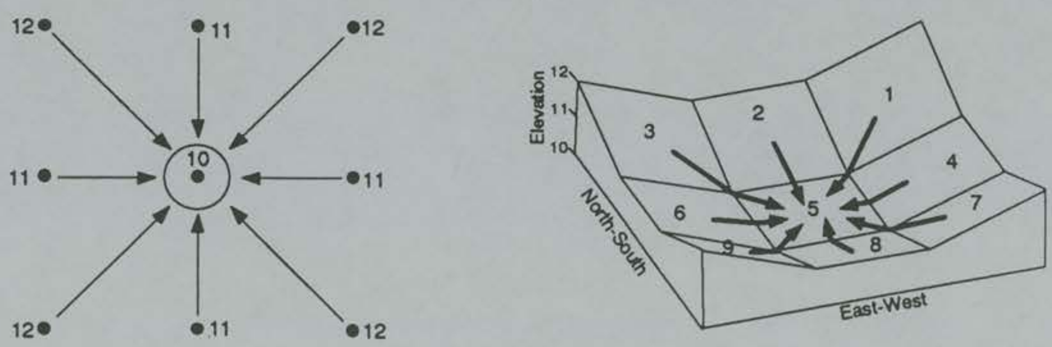
a) Calculation of local drain direction (LDD) as weighted drop to lowest downslope neighbour in 3 x 3 window. Direction (x) represents the greatest weighted drop.



b) Coding scheme used in watershed to identify the local direction of flow.

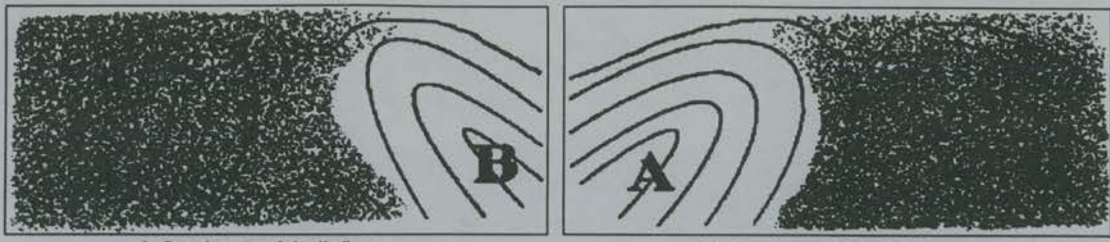


c) Modified approach used to assign local direction of flow to edge cells.

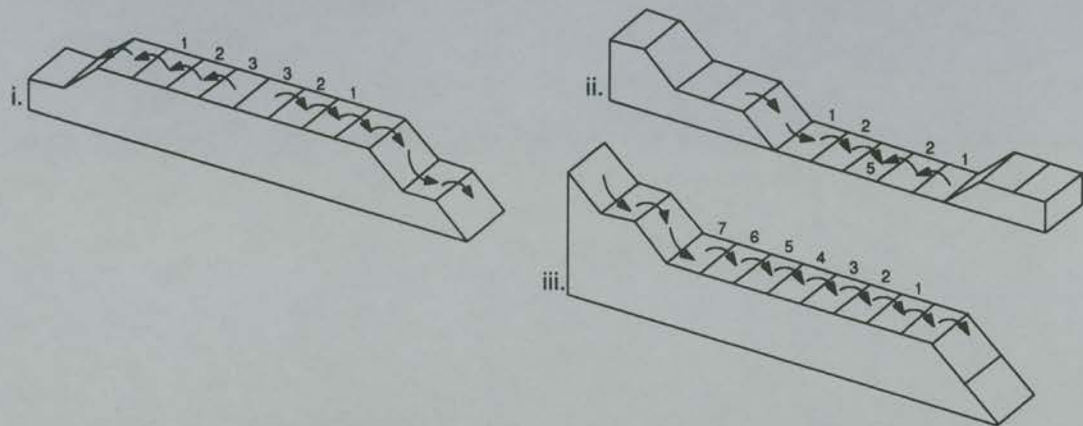


d) Special case: pit cells have no lower neighbours and are assigned a local direction of flow of 5.

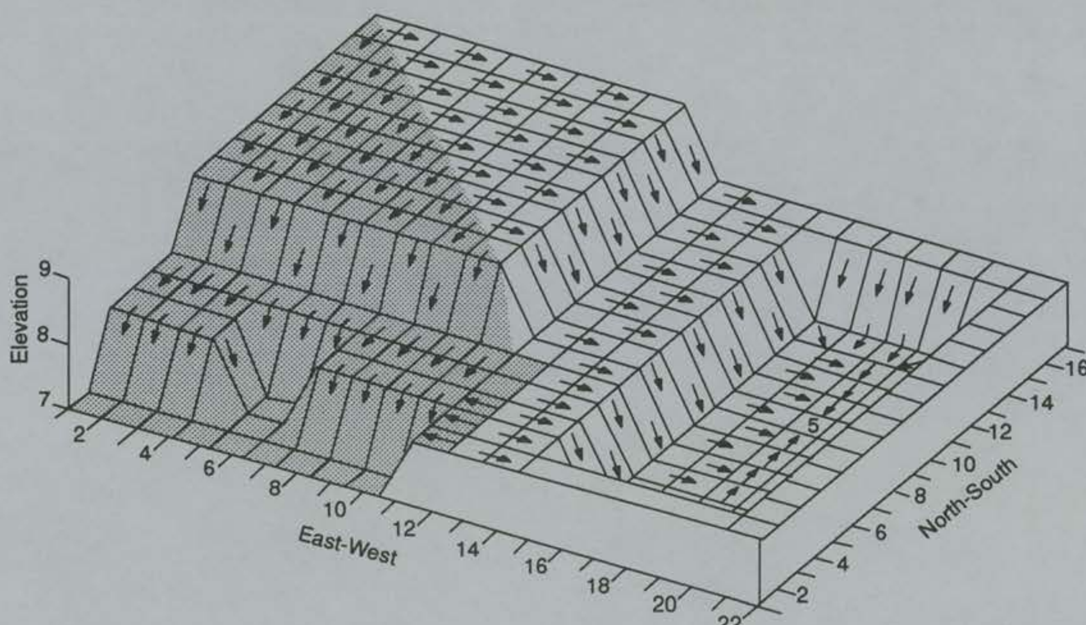
Figure 4.7 Computing and assigning local direction of flow to grid cells.



a) Illustration of the problem of unequal watershed delineation caused by bias in how most algorithms assign flow directions to flat areas (from Wood, 1990a, p.22).

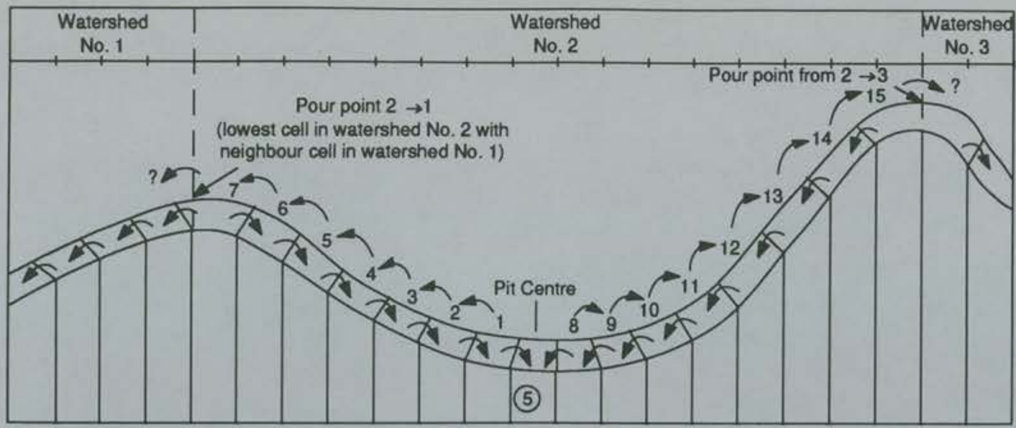


b) Illustration of the stepwise approach implemented in watersheds for assigning a local direction of flow to flat cells.

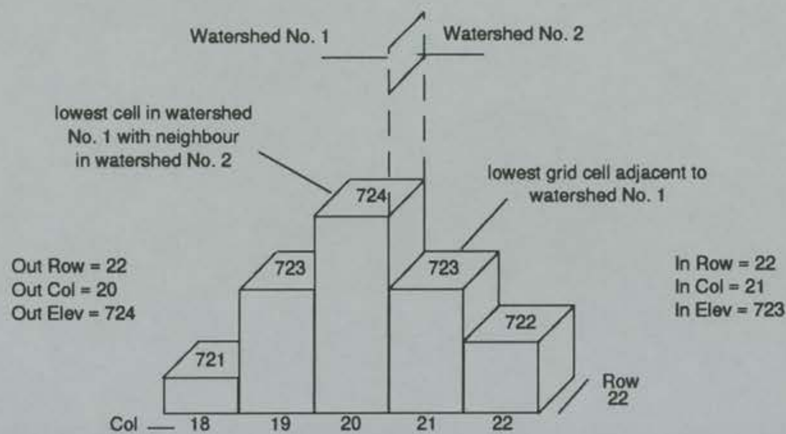


c) Illustration of the effect of the algorithm for dealing with flat cells when applied to a hypothetical extreme case of predominantly flat cells.

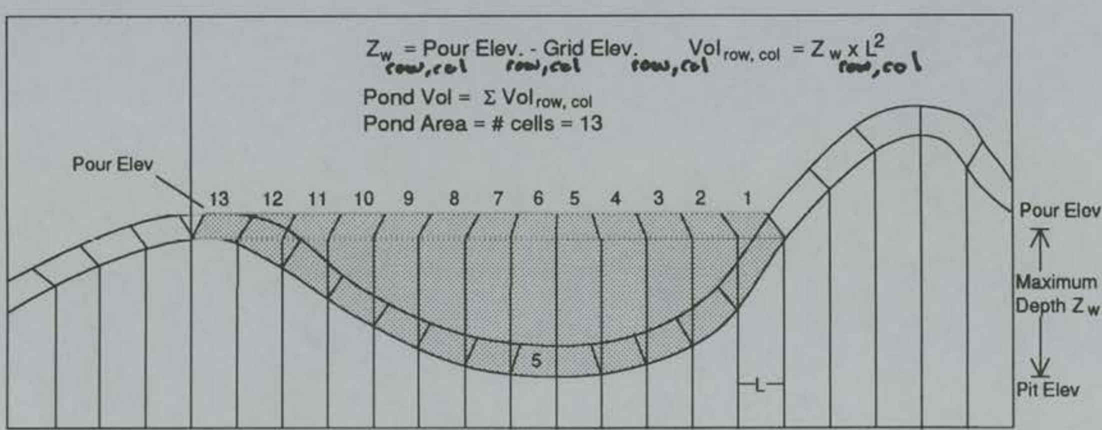
Figure 4.8 Problems and solutions in assigning local direction of flow to flat cells.



a) Locating pour points: algorithm Find-Outlet-Points climbs upslope from pit centre following reverse of local drain directions looking for lowest cell in current watershed with neighbour cell in a different adjacent watershed.

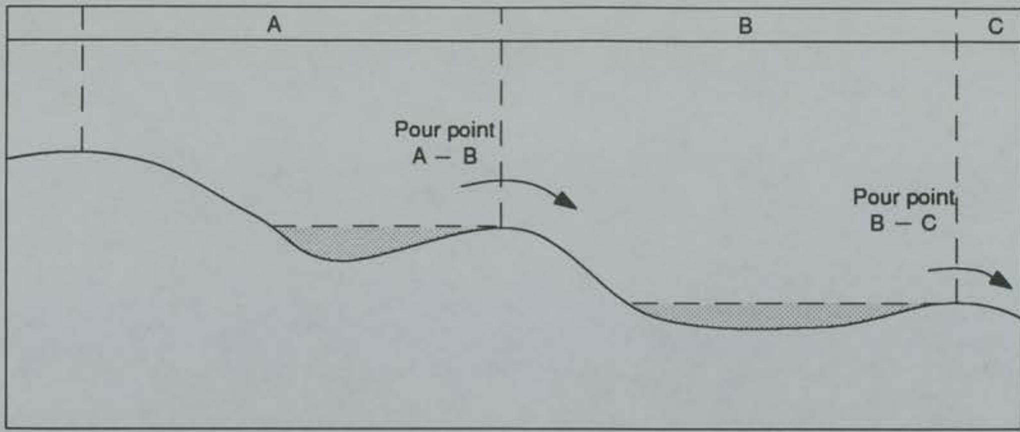


b) Determining pour elevation: Pour elevation is elevation of the higher of the two neighbour cells at a potential overspill location. Water in pond must exceed higher elevation before overspill will occur.

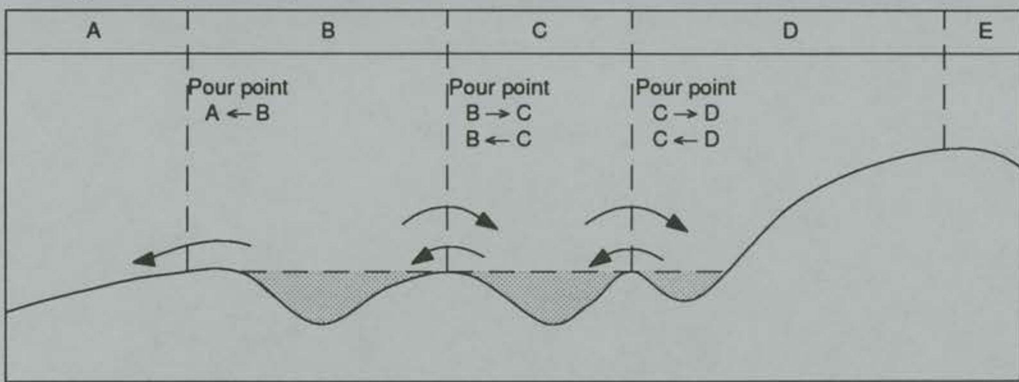


c) Computing pond statistics: pond volume, pond area, overspill elevation, overspill location, maximum depth.

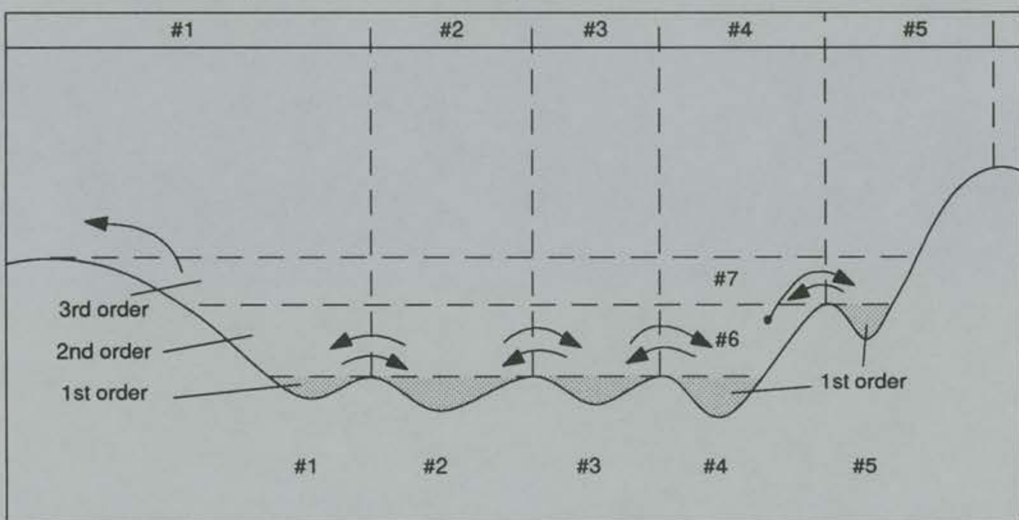
Figure 4.9 Locating pour points and computing watershed statistics.



a) Simple connectivity: Depression has only one "lowest" pour point and overspills into neighbouring downslope catchment when full.

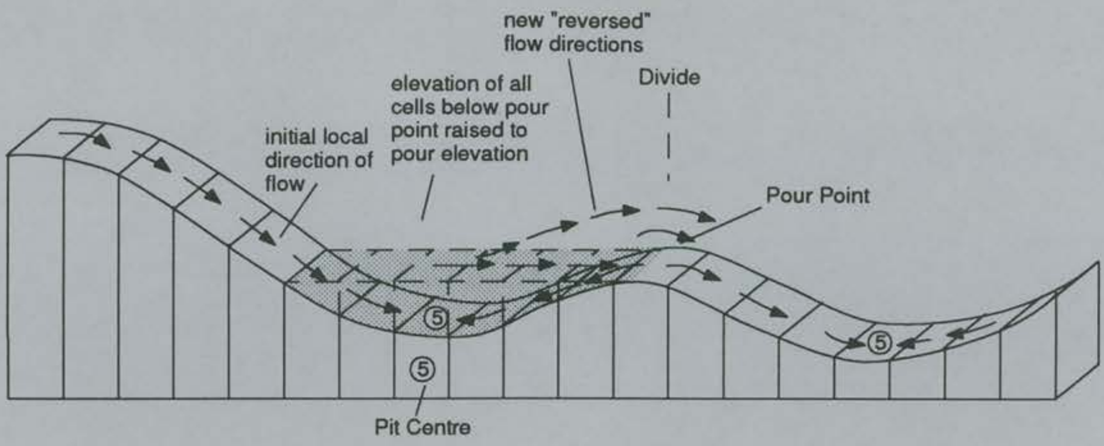


b) Complex connectivity: Neighbouring depressions share multiple pour points of identical elevation and overspill into two or more neighbours when full.

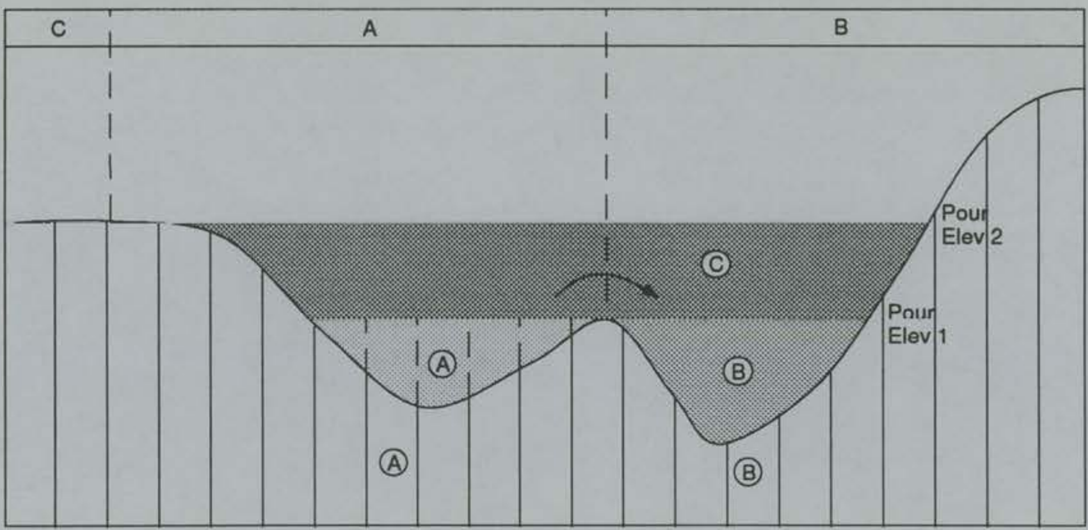


c) Nested depressions: Several neighbouring ponds coalesce and have no outlet lower than their common pour elevation. The new pond must now flood to a new, higher pour elevation to overspill.

Figure 4.10 Illustration of types of pond connectivity including nested depressions.

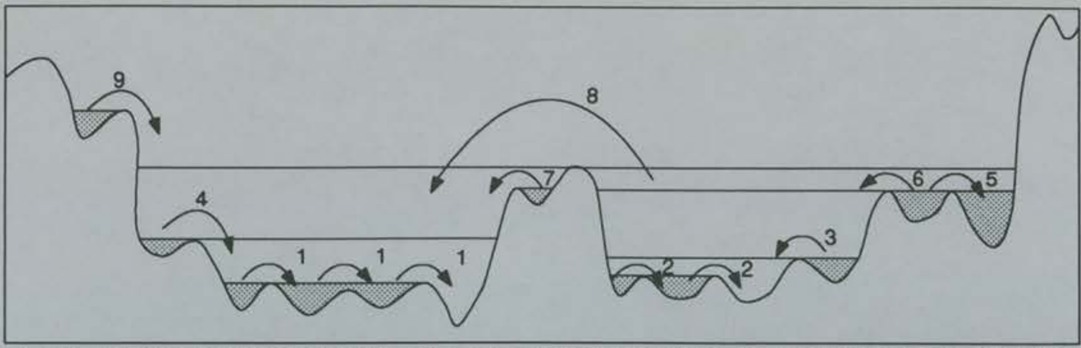


a) Pit Removal Procedure: Works by "tracing down" flow path from pour point to depression centre, reversing the local direction of flow of each cell on the path so that it points back into the previous cell in the flow path.

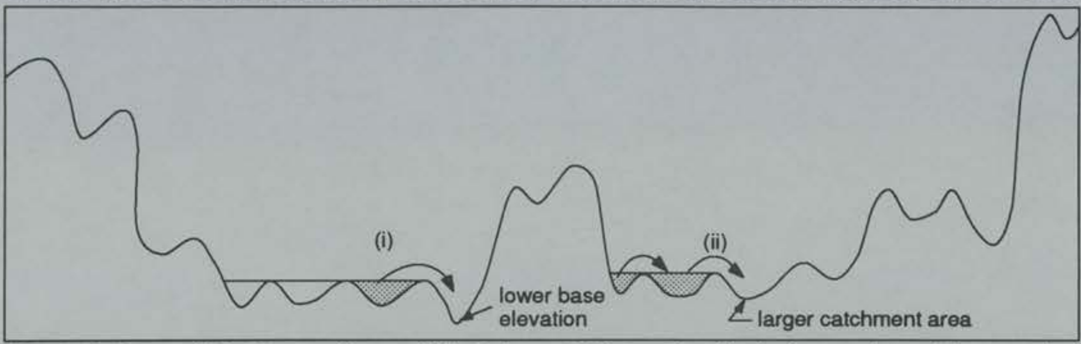


b) Computing volume of new "higher order" subsuming pit after coalescence of "nested pits". Elevation in pit A is raised to equal pour elevation 1 before computing volume of new pit. New volume = vol. B + vol. C. Does not include volume A. Must add vol. A to get total volume of new pit, subtract volume B to get incremental difference in volume of new pit over the previous volume of pits A + B. Volume C is called Vol-to-Flood in the pond statistics table and represents the additional or incremental volume required to flood the new "higher order" pit once pits A + B are full.

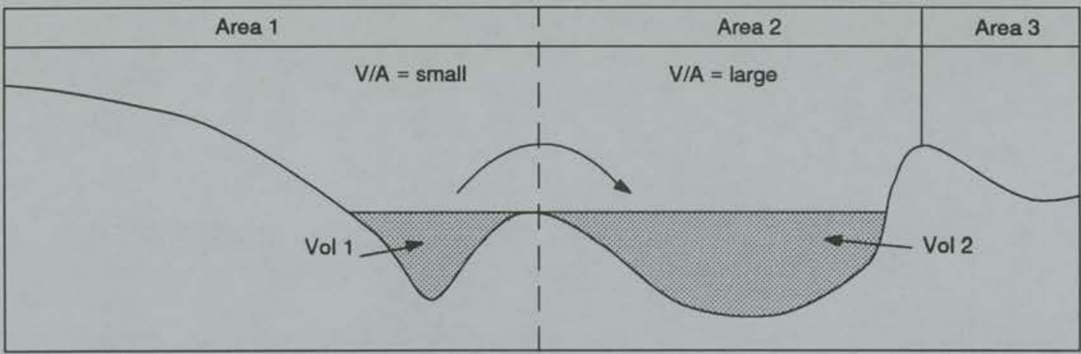
Figure 4.11 Illustration of procedures used too remove pits and to recompute pond volume for new nested pits.



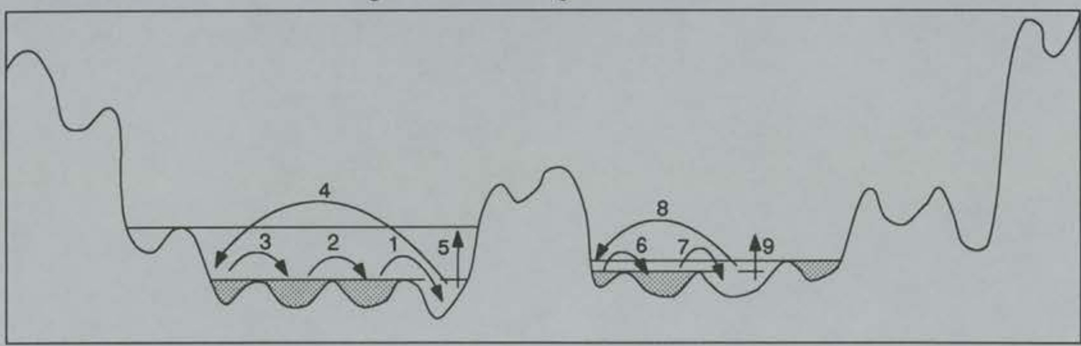
a) Rule 1: Pits always removed in order of pour elevation from lowest to highest pour elevation.



b) Rule 2: Overspill is always directed INTO the neighbour pit with the lowest base (pit centre) elevation (i) OR if all base elevations are the same, into the pit with the largest catchment area (ii).



c) Rule 3: Where rules 1 or 2 don't force a decision, then flow is directed from the pit with the smaller V/A-Ratio into the neighbour with a larger V/A-Ratio.



d) Rule 4: Pointers must be selected in such a way that they always impose 'circular' flow before pointing up to a "higher" pit.

Figure 4.12 Illustration of the rules of thumb applied when removing pits.

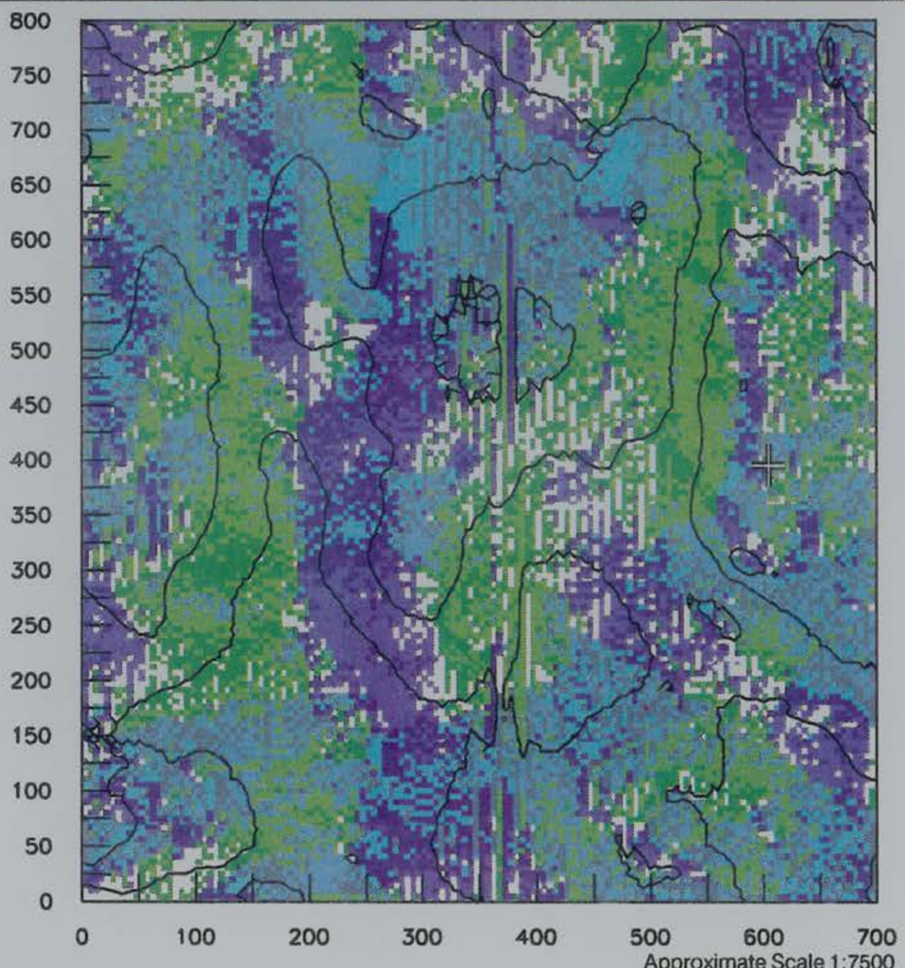


Figure 4.13 Local direction of flow (LDD) for all grid elements of the Lunty site DEM, perspective view (top), plan view (bottom).

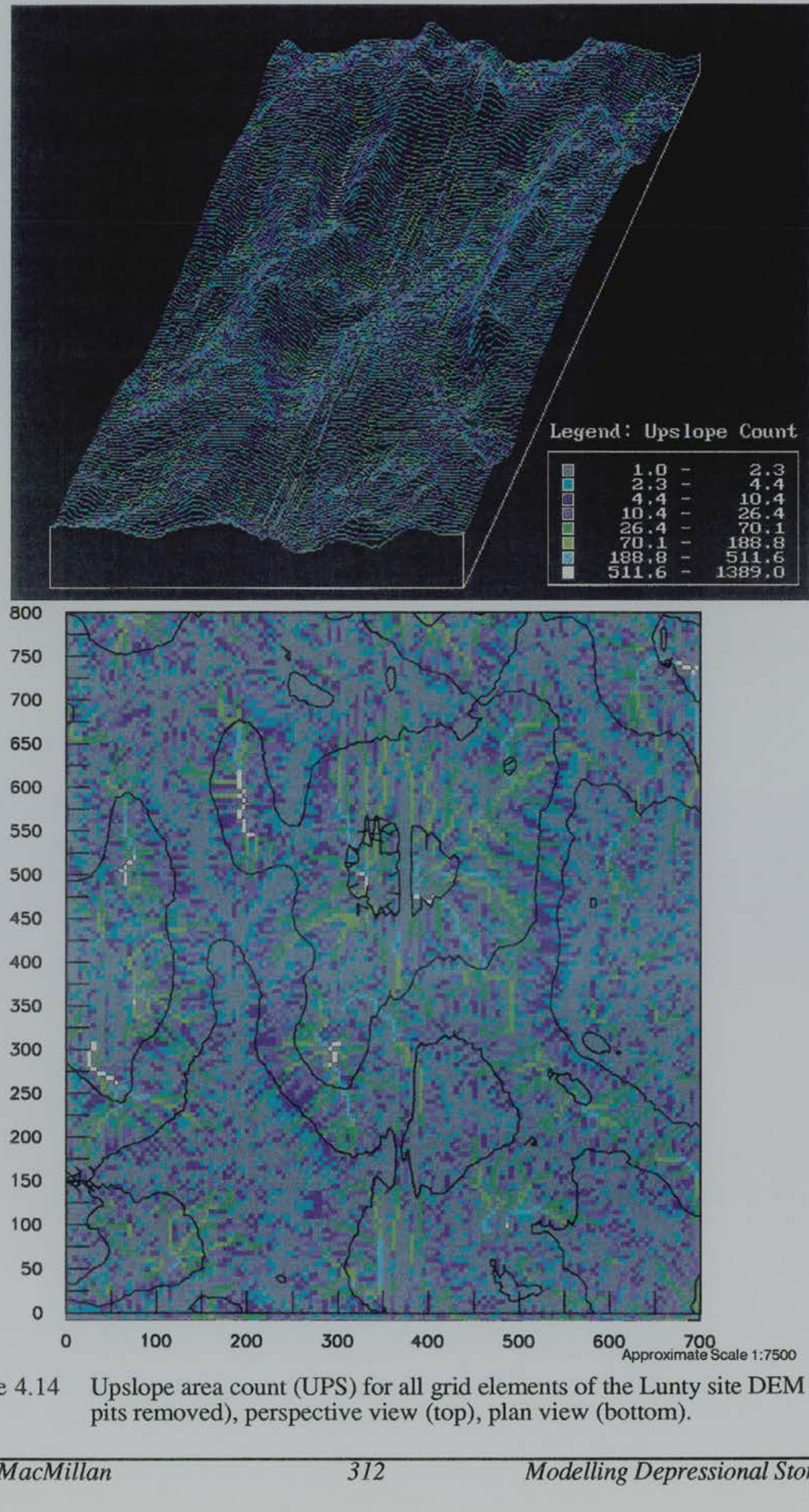


Figure 4.14 Upslope area count (UPS) for all grid elements of the Lunty site DEM (no pits removed), perspective view (top), plan view (bottom).

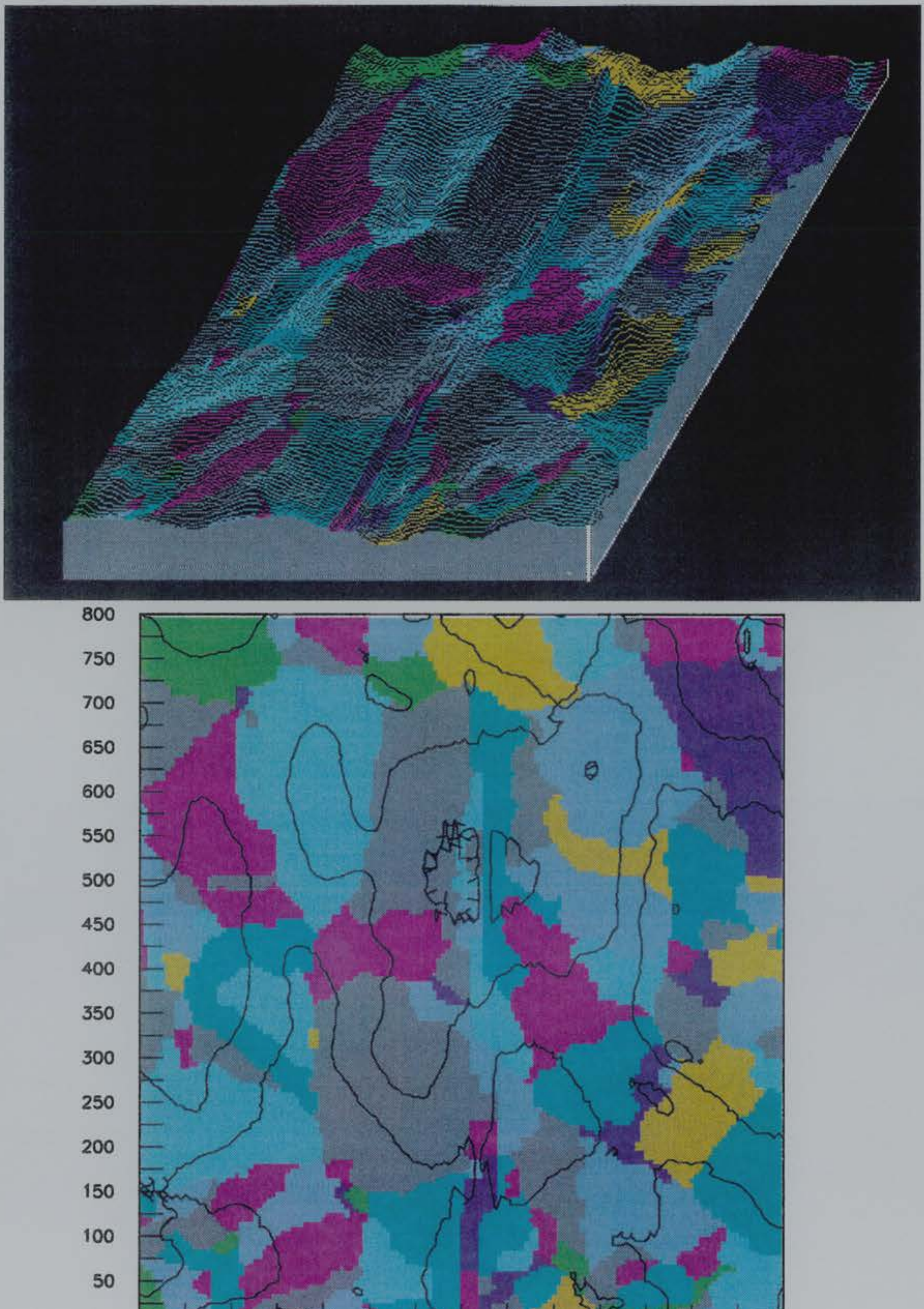


Figure 4.15 Location and extent of watersheds for the 115 initial depressional catchments at the Lunty site 3D view (top), plan view (bottom).

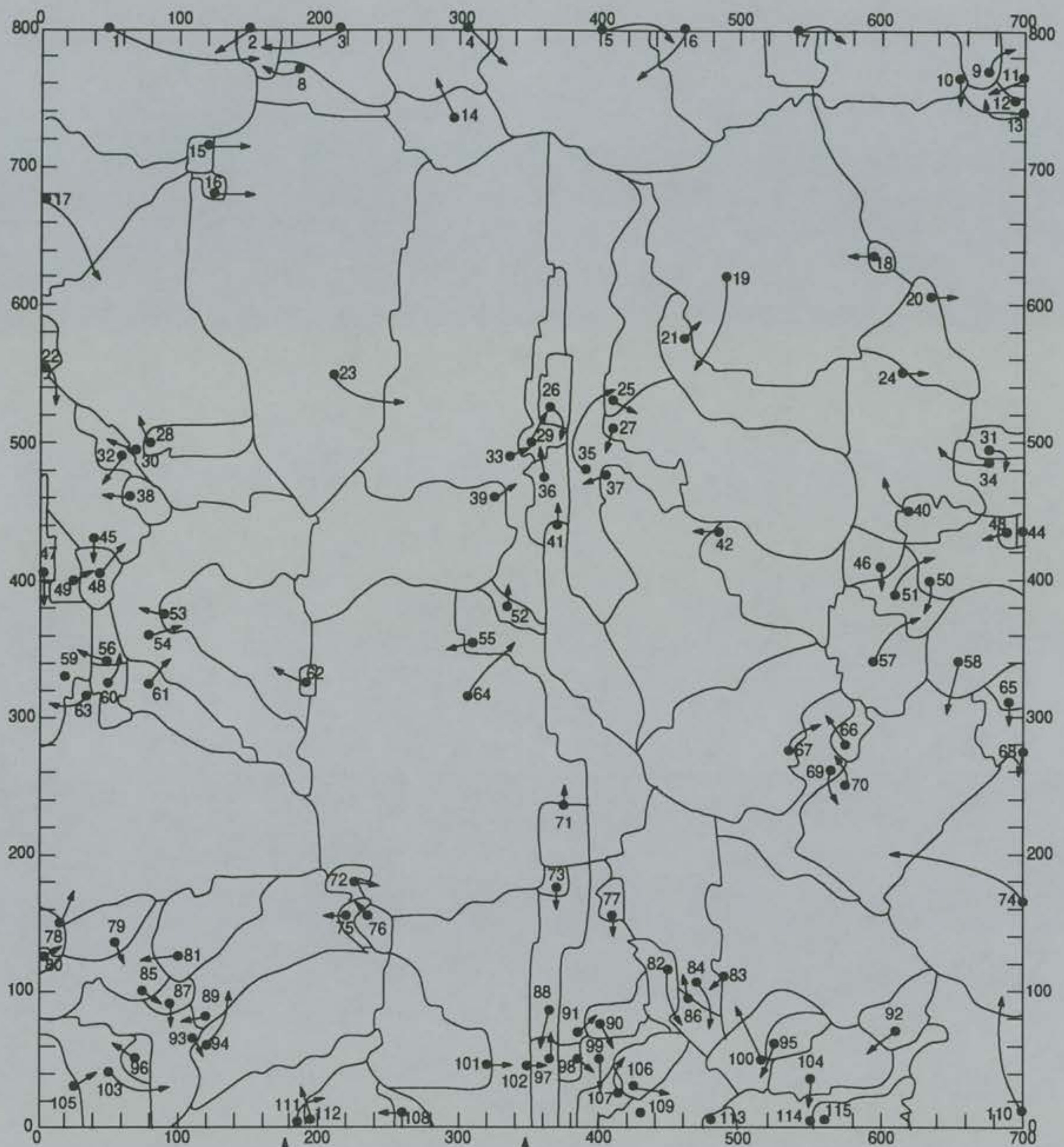


Figure 4.16 Illustration of connectivity among the 115 initial depressional catchments at the Lunty site.

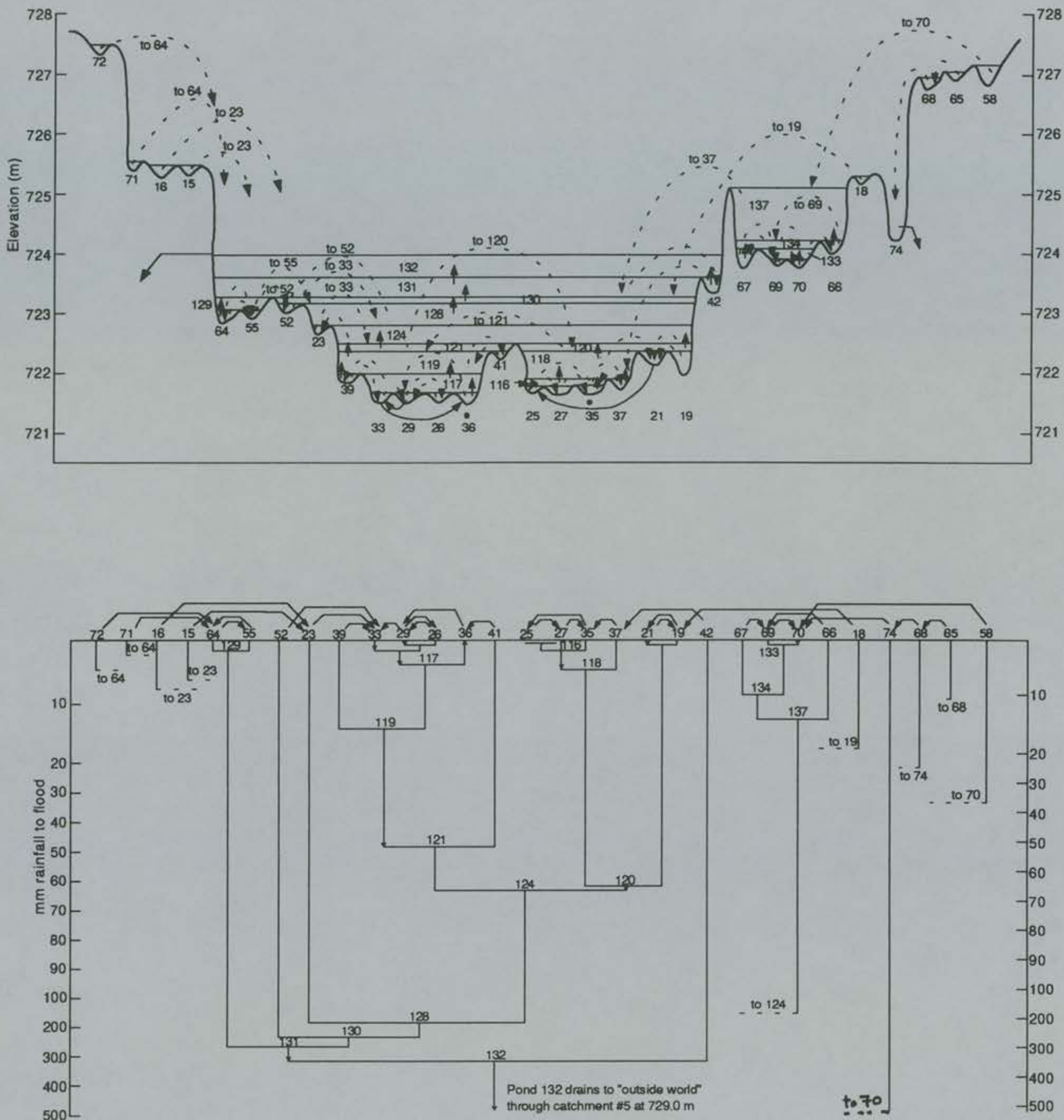


Figure 4.17 Schematic illustration of pond connectivity and nested depressions for interior catchments contributing flow to the main central depression (Pit no. 36).

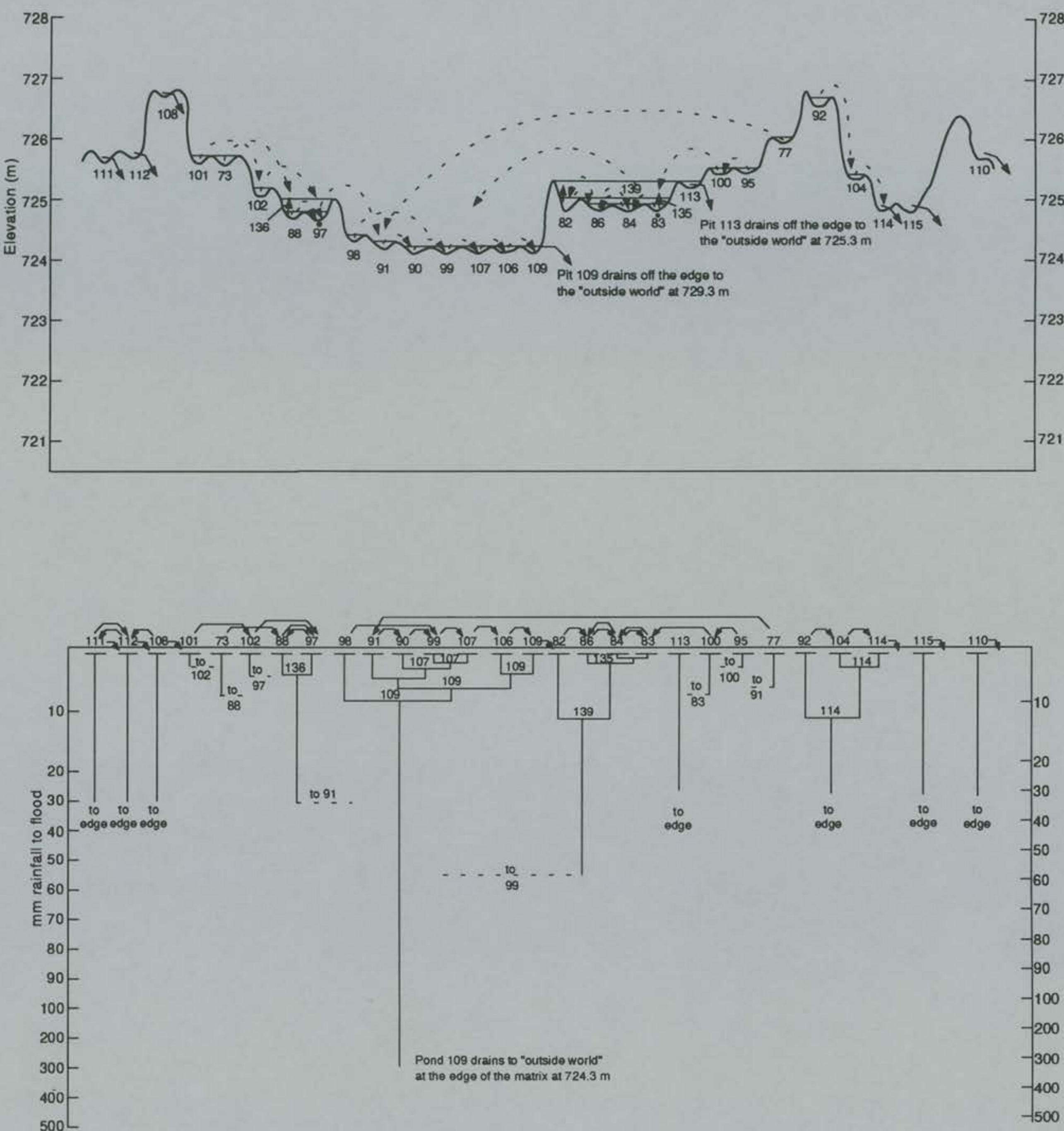


Figure 4.18 Schematic illustration of pond connectivity and nested depressions for catchments contributing flow to the southern edge of the study area (at catchment 109).

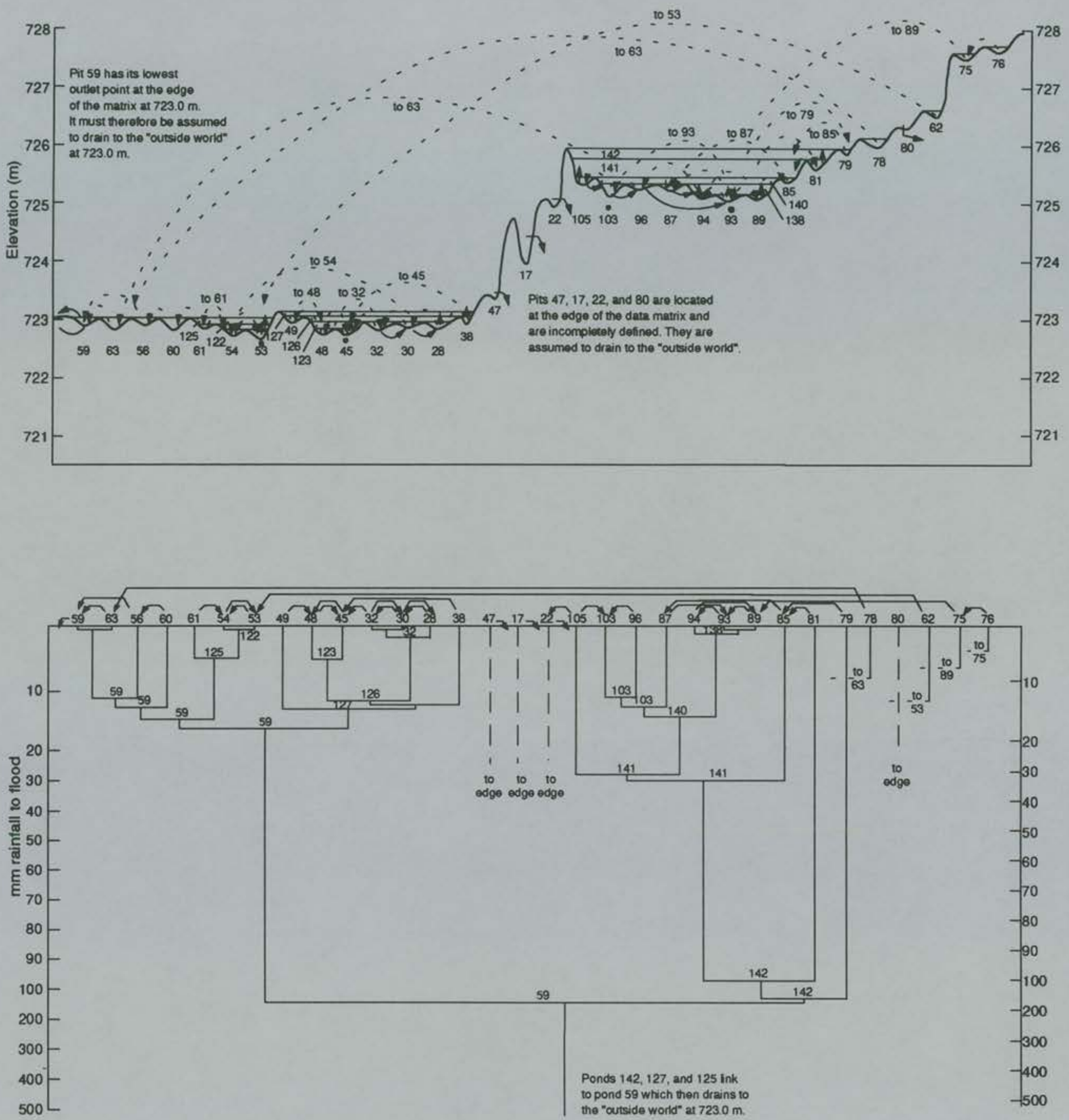


Figure 4.19 Schematic illustration of pond connectivity and nested depressions for catchments contributing flow to the western edge of the study area (at catchment 59).

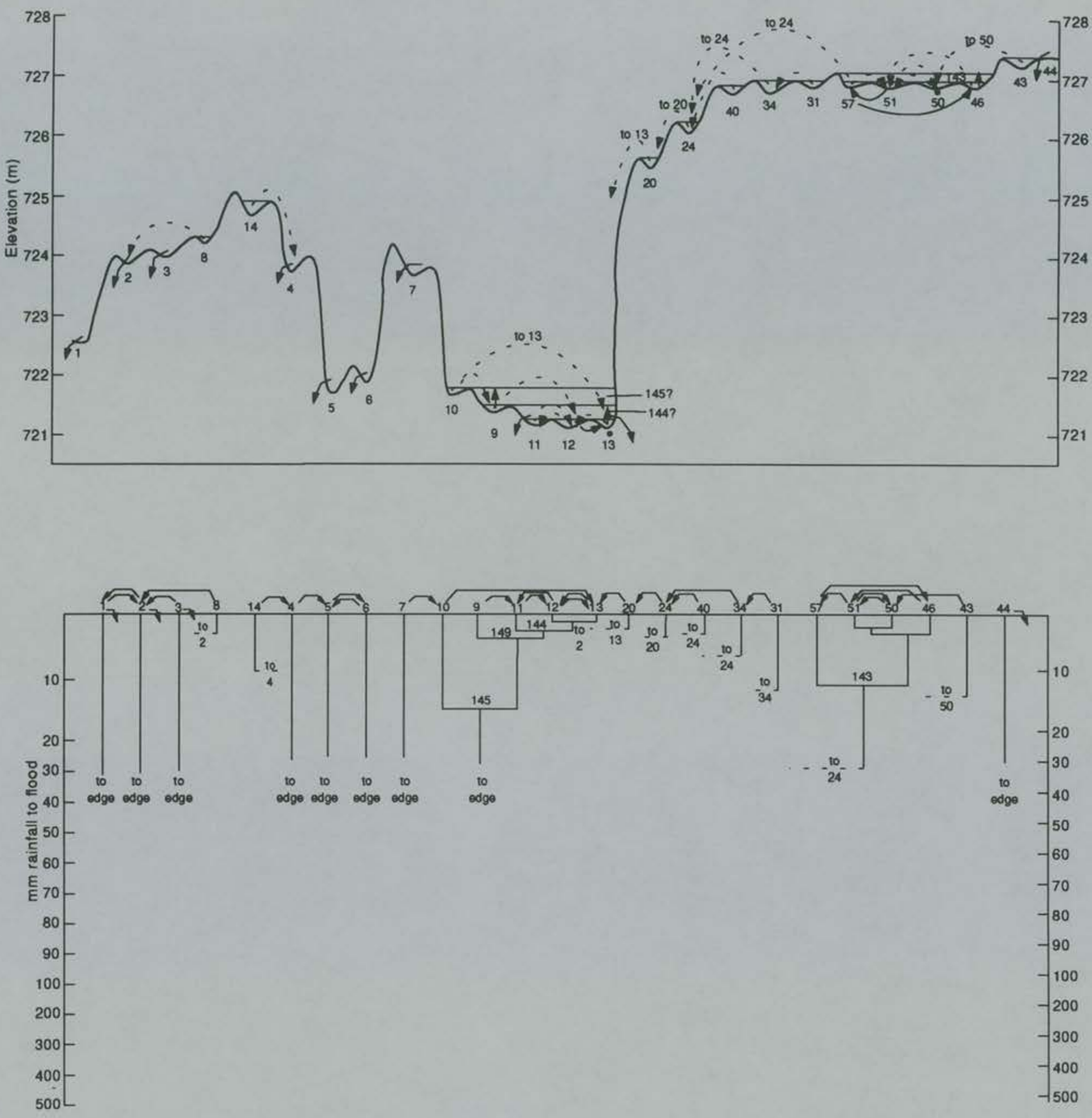


Figure 4.20 Schematic illustration of pond connectivity and nested depressions for catchments contributing flow to the northern edge of the study area (at Pit no. 13).

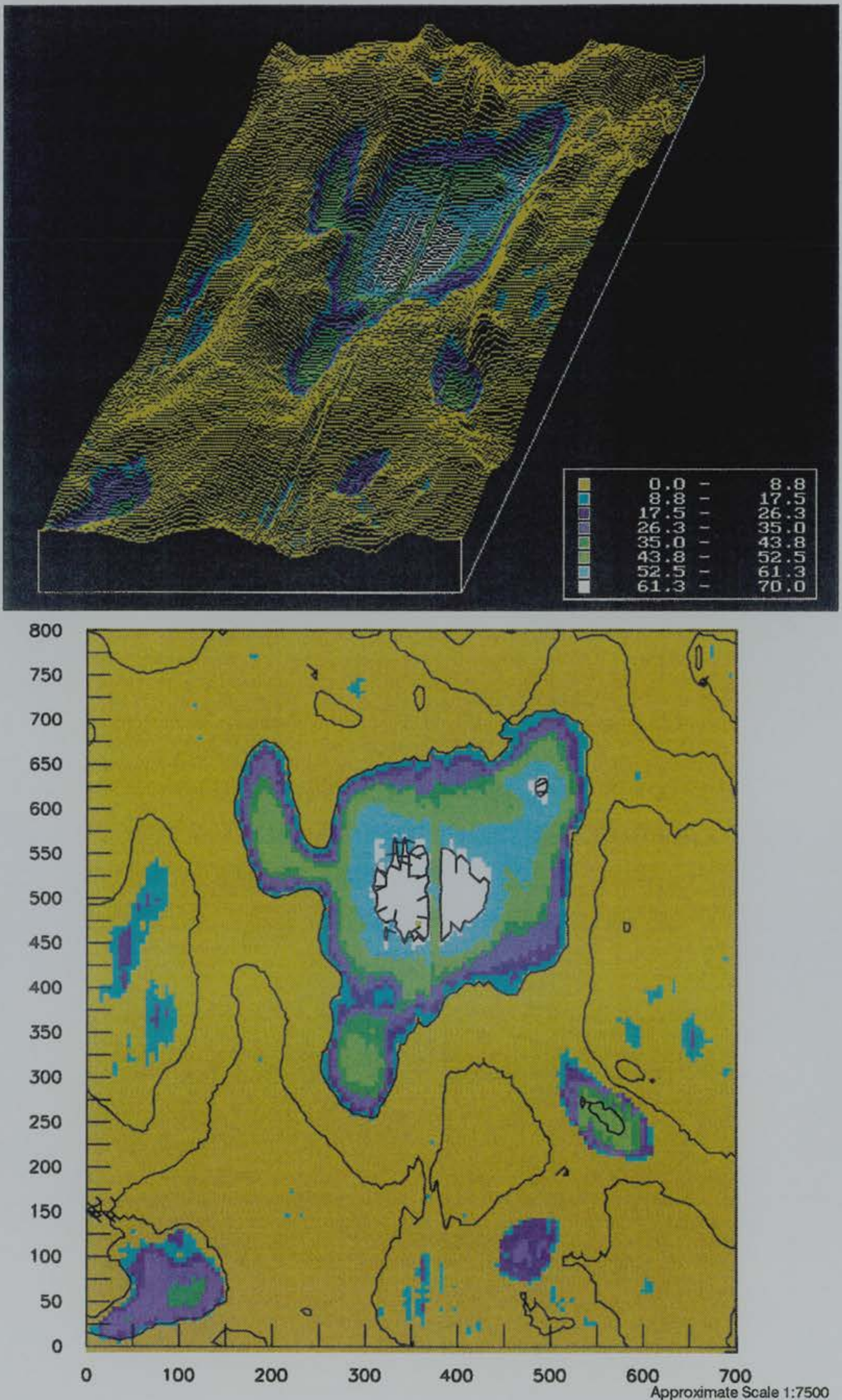


Figure 4.21 Location and maximum extent of depressional ponding as computed for the Lunty site; 3D view (top), plan view (bottom).

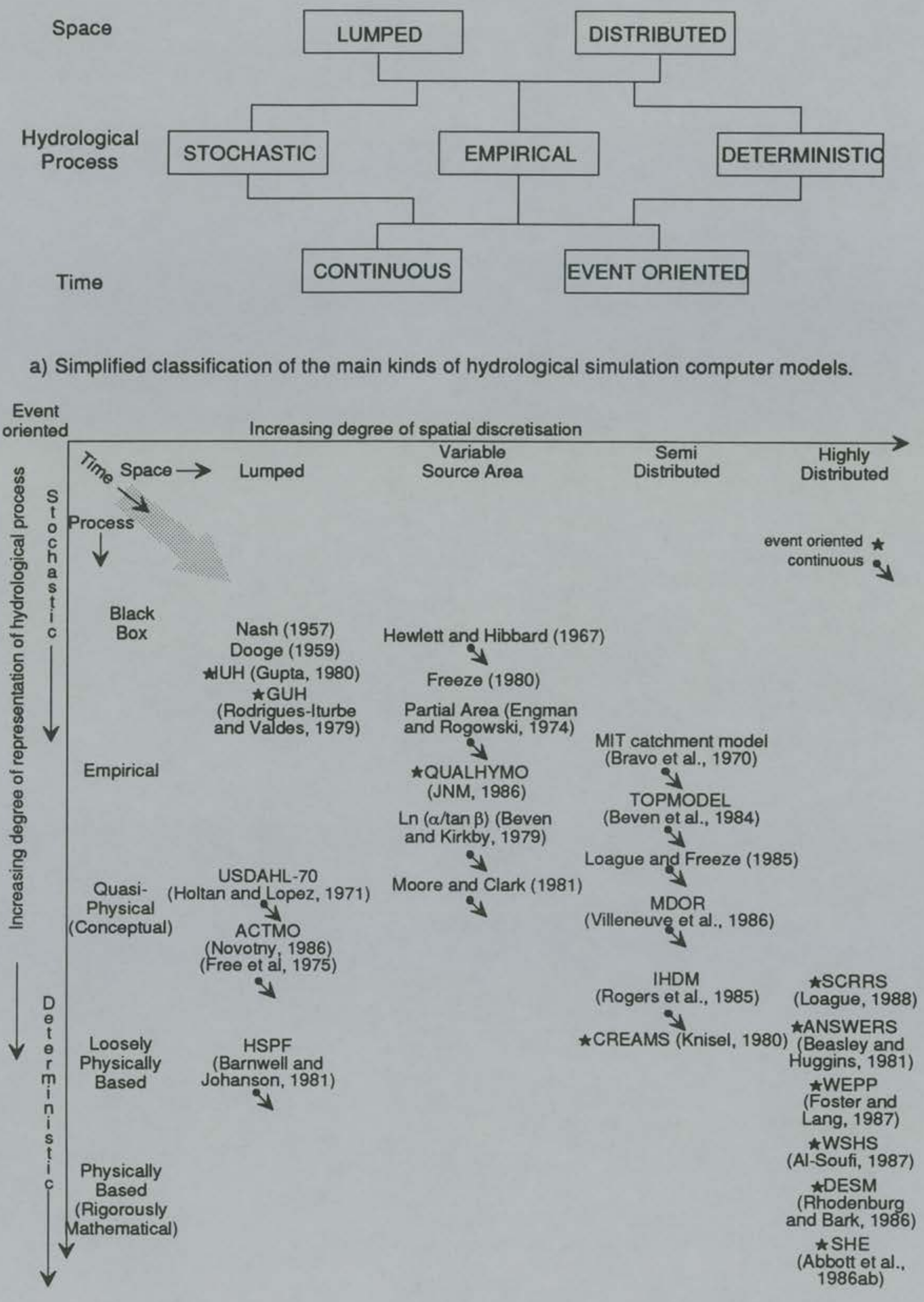
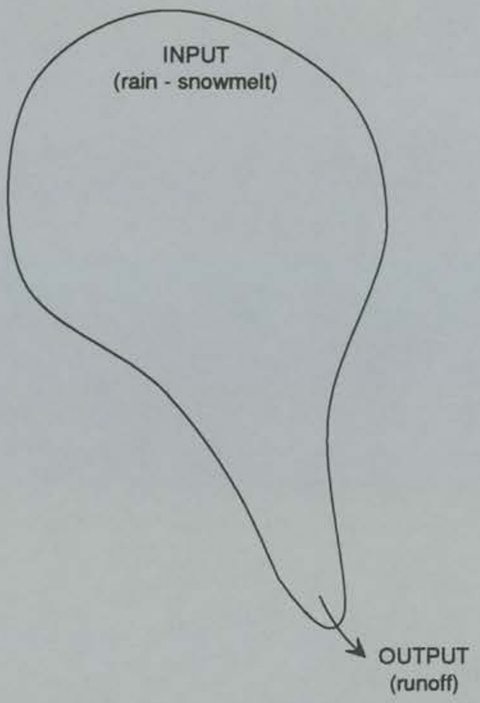


Figure 5.1 Classification of hydrological simulation models with respect to space, hydrological process and time.

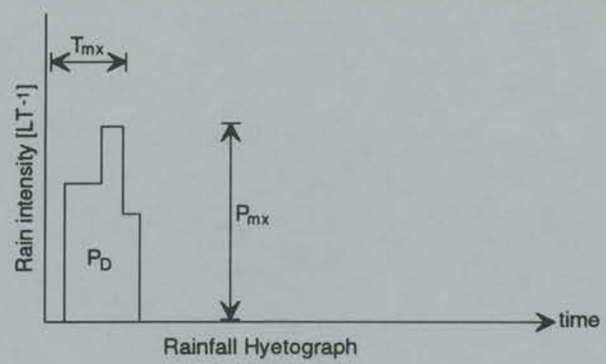


$a_1, a_2 \ldots a_n$ = non physically based calibration parameters

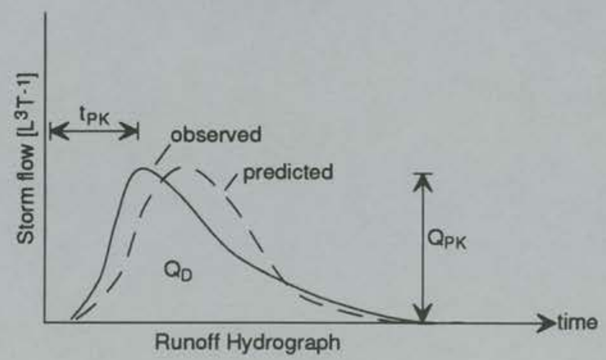
$b_1, b_2 \ldots b_n$ = physically based parameters, ie. soil hydraulic conductivity, soil storage capacity, land use/land cover, evapotranspiration.

a) $Q_{m+1}(+) = f\,[P_{m+1}(+); a_1 + a_2, \ldots a_n, b_1, b_2 \ldots b_n]$

b) $[Q_D, Q_{PK}, t_{PK}]_{m+1} = f\,[(P_D, P_{MX}, t_{MX})_{m+1}; a_1, a_2, \ldots a_n, b_1, b_2, \ldots b_n]$

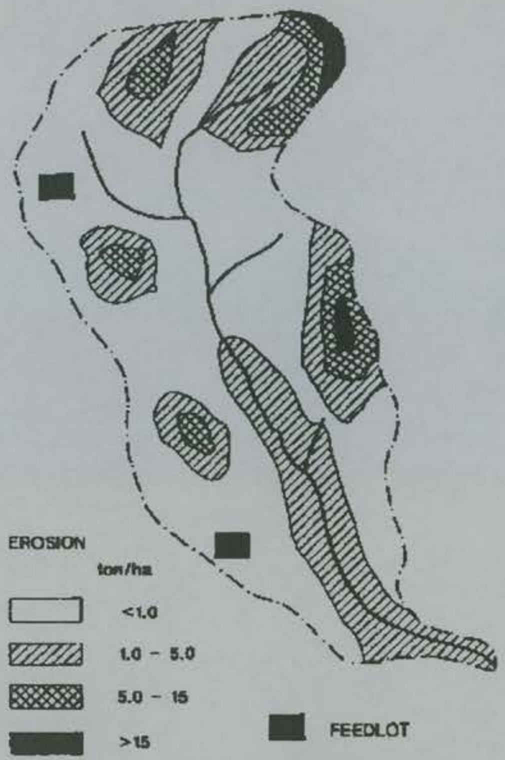


P_D = total rainfall depth [L]
P_{mx} = maximum rainfall intensity [L/T]
t_{mx} = time to end of P_{mx} from beginning of event [T]

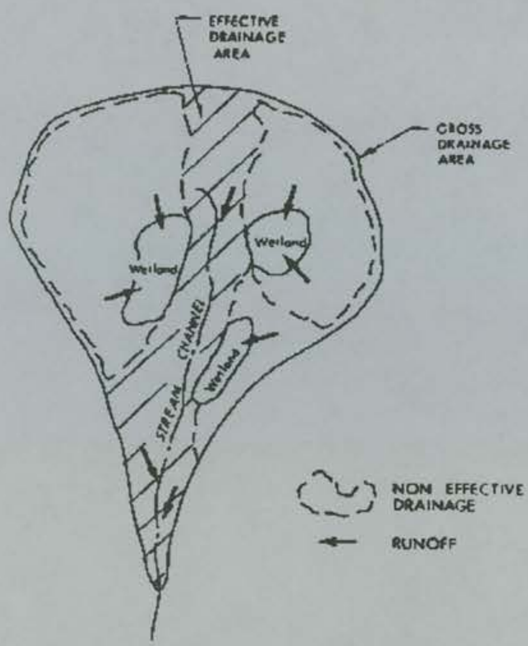


Q_D = total stormflow depth calculated as volume of flow divided by total catchment area (L)
Q_{PK} = peak stormflow rate ($L^3 T^{-1}$)
t_{PK} = time to Q_{PK} from beginning of event (T)

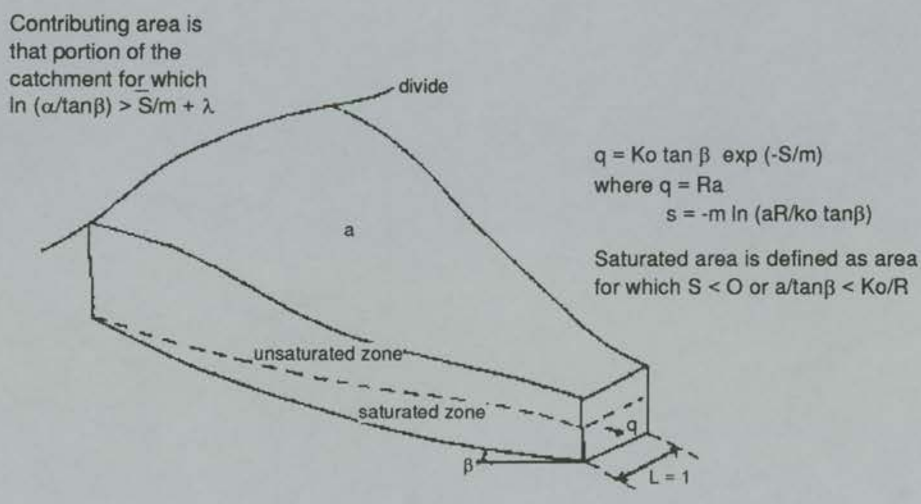
Figure 5.2 Illustration of the representation of space commonly adopted by some aspatial, lumped parameter models (modified after Loague and Freeze, 1985).



a) Illustration of the variable source area concept (after Novotny, 1980).

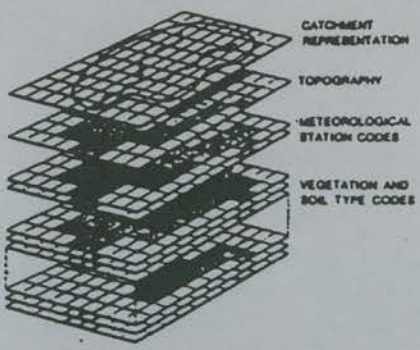


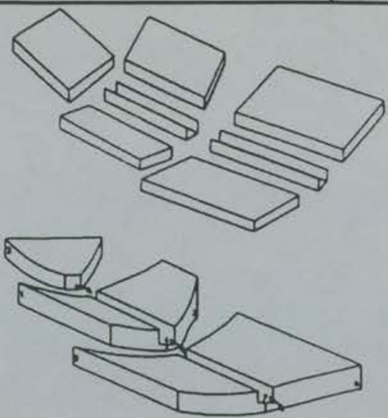
b) Illustration of variable source areas (defined as effective drainage area) controlled by depressional storage as conceptualized for the model OTTHYMO (after JNM, 1986).



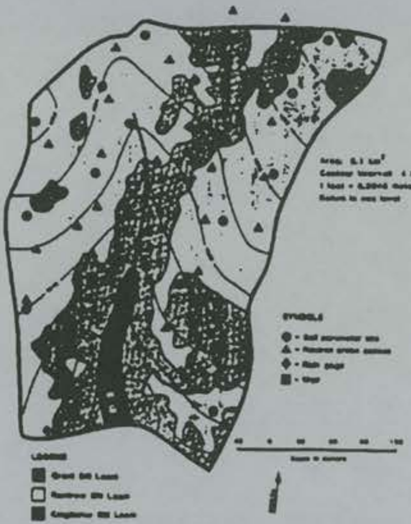
c) Illustration of variable source area expressed as a dynamic catchment characteristic calculated from catchment geomorphology (after Beven and Wood, 1983).

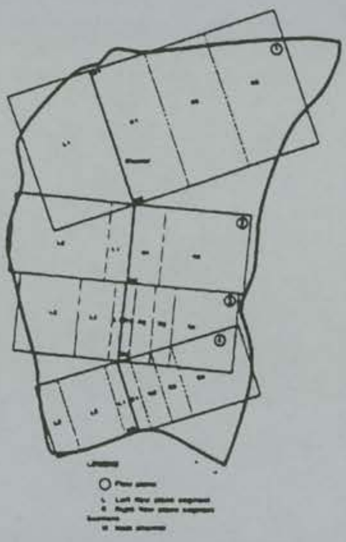
Figure 5.3 Illustration of the representation of space commonly adopted by some example variable source area hydrological models.



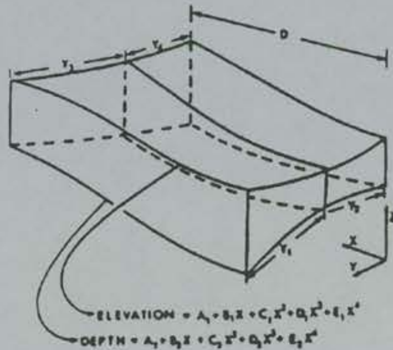


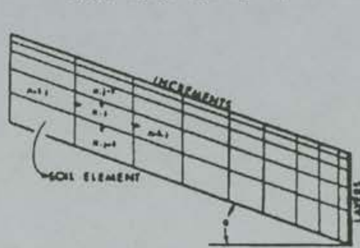
a) Simple, highly idealized catchment representation adopted by the Institute of Hydrology Distributed Model (IHDM) (after Anderson and Rogers, 1987, pp. 32-33).





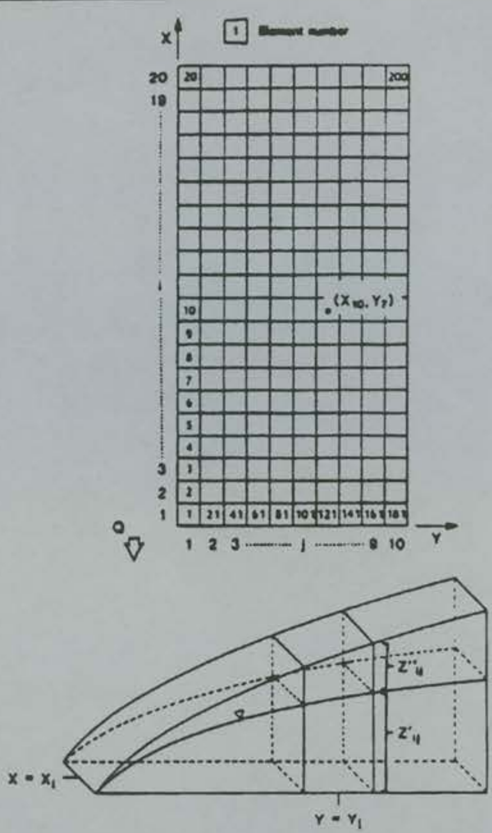
b) Illustration of the slightly more complex spatial representation of catchment components adopted by Loague and Freeze (1985) p. 234.



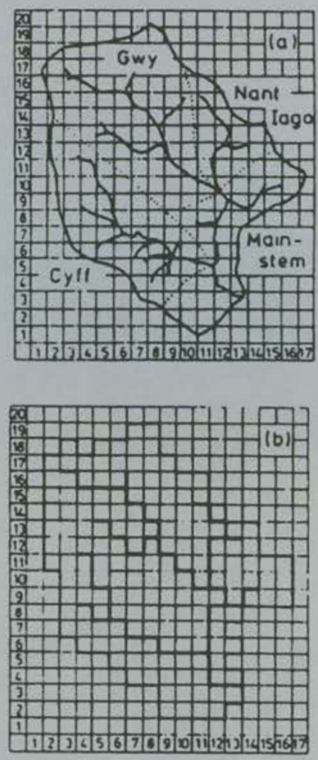


c) Illustration of the quite detailed but still highly idealized spatial representation of catchment components adopted for the model VSAS2 (after Bernier, 1985) p. 202-203.

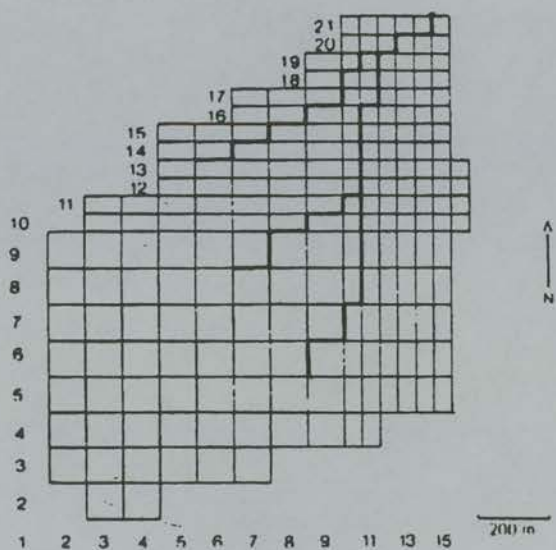
Figure 5.4 Illustration of the representation of space commonly adopted by some example semi-distributed hydrological models.



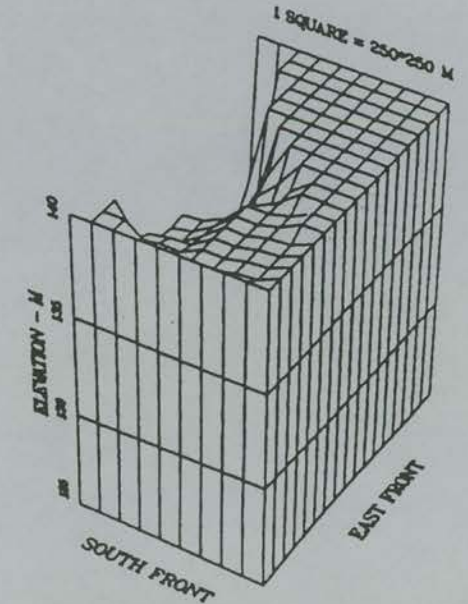
a) Fixed, 2-dimensional grid element representation utilized by SCRRS (after Loague, 1988, pp. 1502, 1504).



b) Fixed 2-dimensional grid representation of the Wye catchment used in conjunction with the SHE Model (after Bathurst, 1986, p.81). Grid elements are 250 m x 250 m.

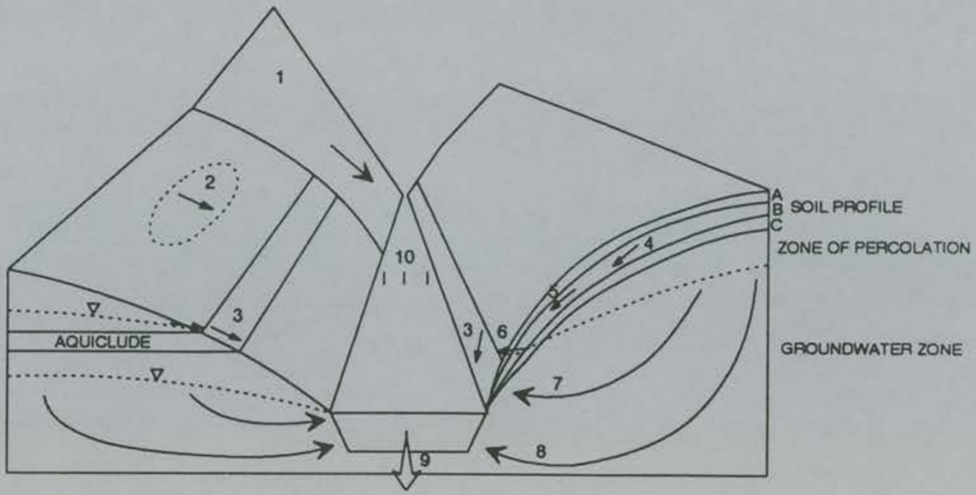


c) Variable speed 2-dimensional grid representation of the Neuenkirchen catchment used in conjunction with DESIM and SHE (after Rhodenburg et al, 1986, pp.131).



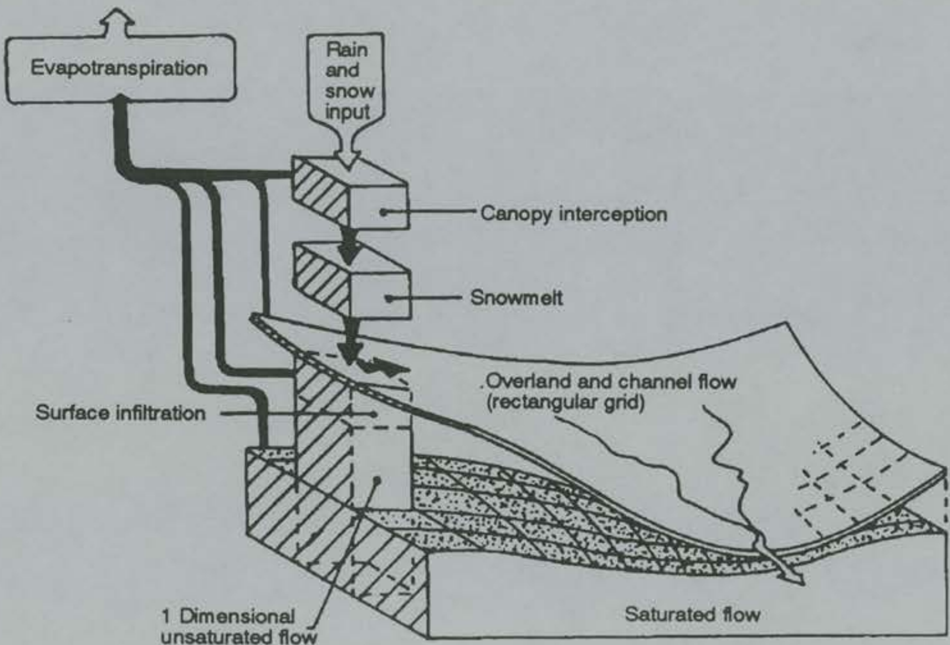
d) Three-dimensional cubic node representation of the Nolsjon catchment (after Al-Soufi, 1987, p.21).

Figure 5.5 Illustration of the representation of space commonly adopted by some example highly-distributed hydrological models.



1. Hortonian overland flow
2. Infiltration excess overland flow
3. Saturation overland flow
4. Unsaturated soil moisture movement
5. Saturated soil moisture movement (subsurface flow)
6. Subsurface return flow (exfiltration)
7. Groundwater seepage flow
8. Groundwater flow
9. Turbulent channel flow
10. Direct channel precipitation

a) Mechanisms of flow contributing to the generation of runoff (after van de Griend and Engman, 1985, p.214).



b) Schematic illustration of the major physical processes involved in controlling runoff (after Abbott et al., 1986a, p.47).

Figure 5.6 Mechanisms and physical processes involved in the generation of surface runoff.

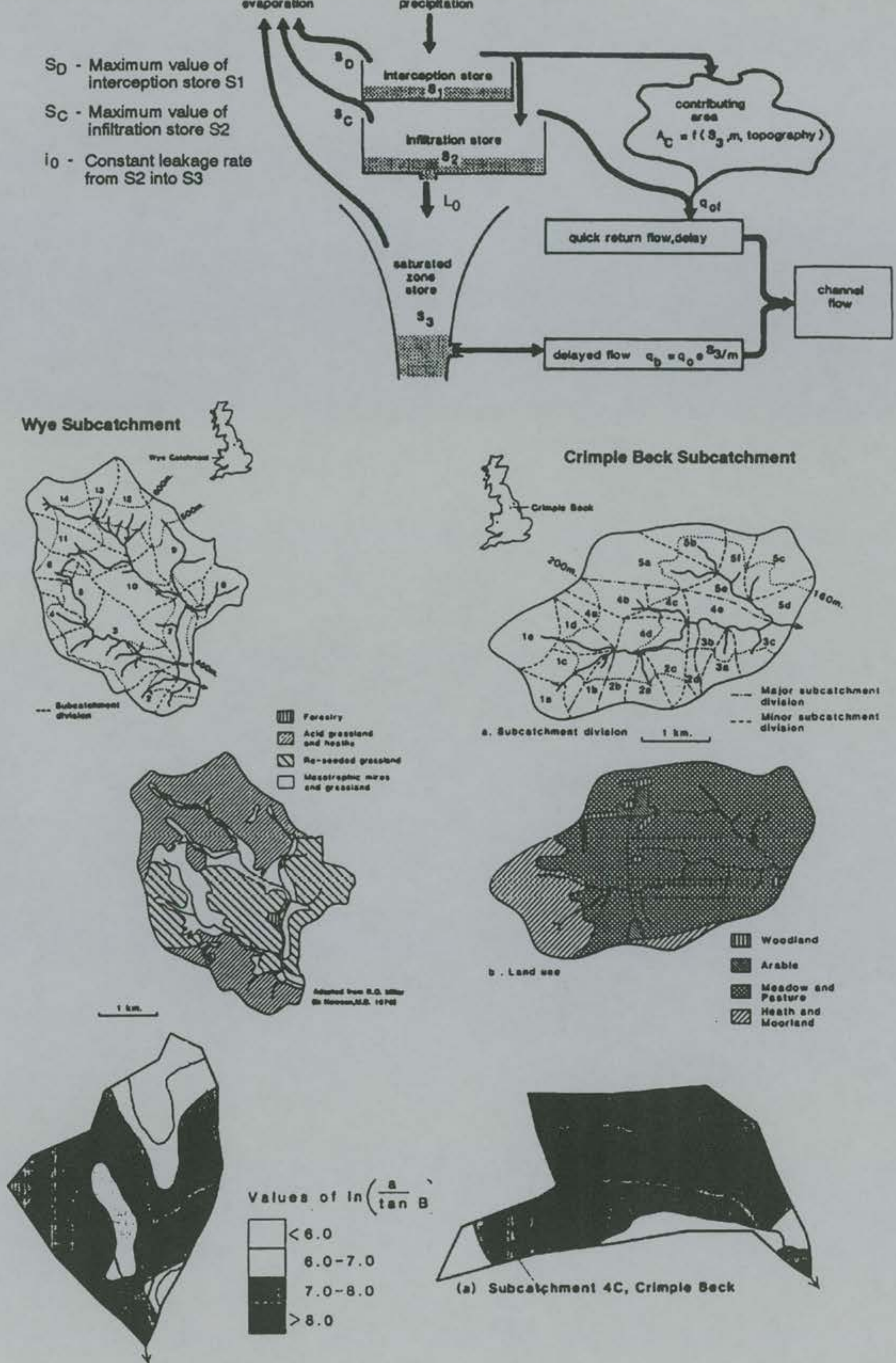


Figure 5.7 Illustration of a conceptual model of cascading storage reservoirs applied to a semi-distributed representation of the Wye and Crimple Beck catchments (after Beven et al., 1984, p. 121, 123, 127 & 130).

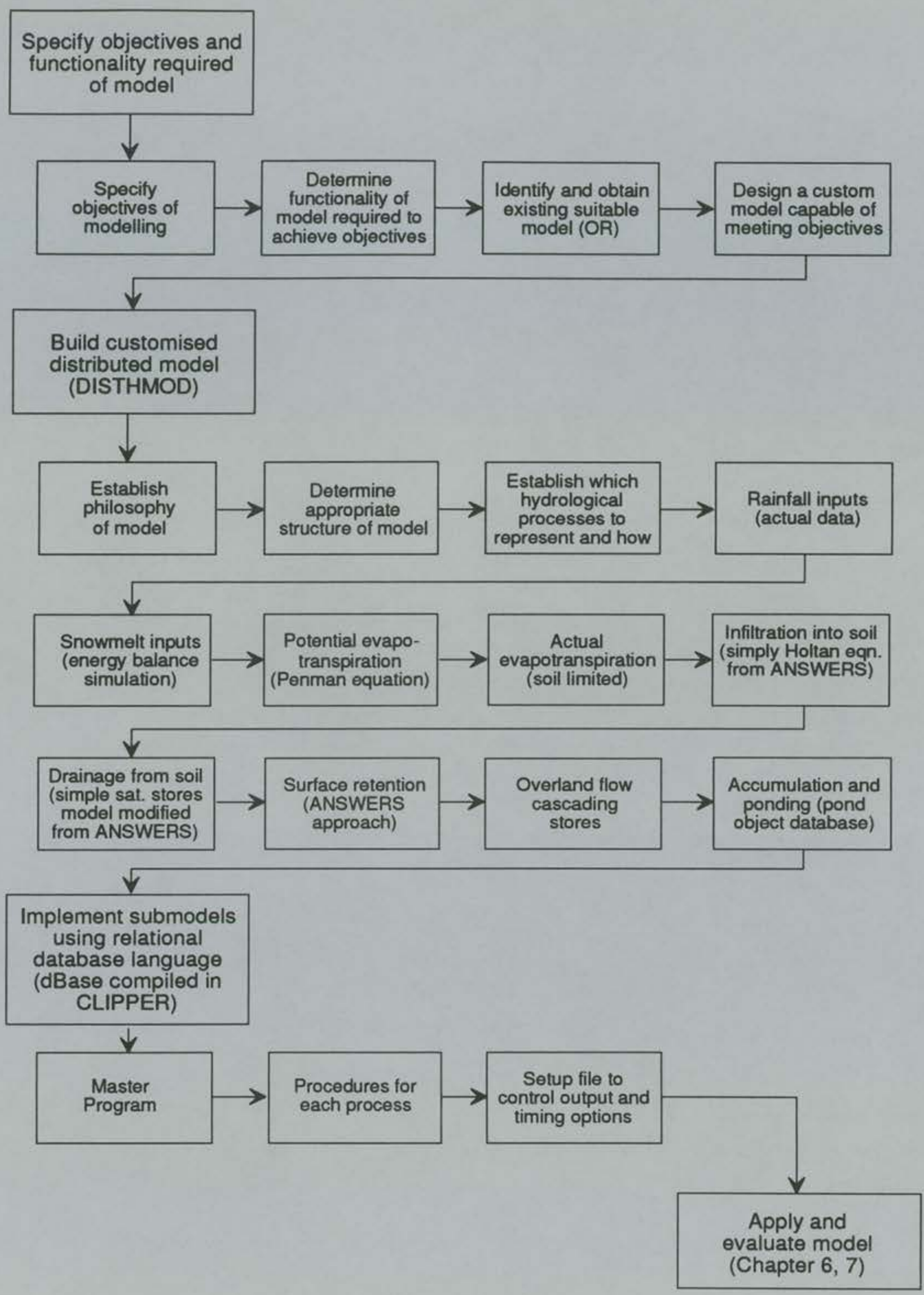
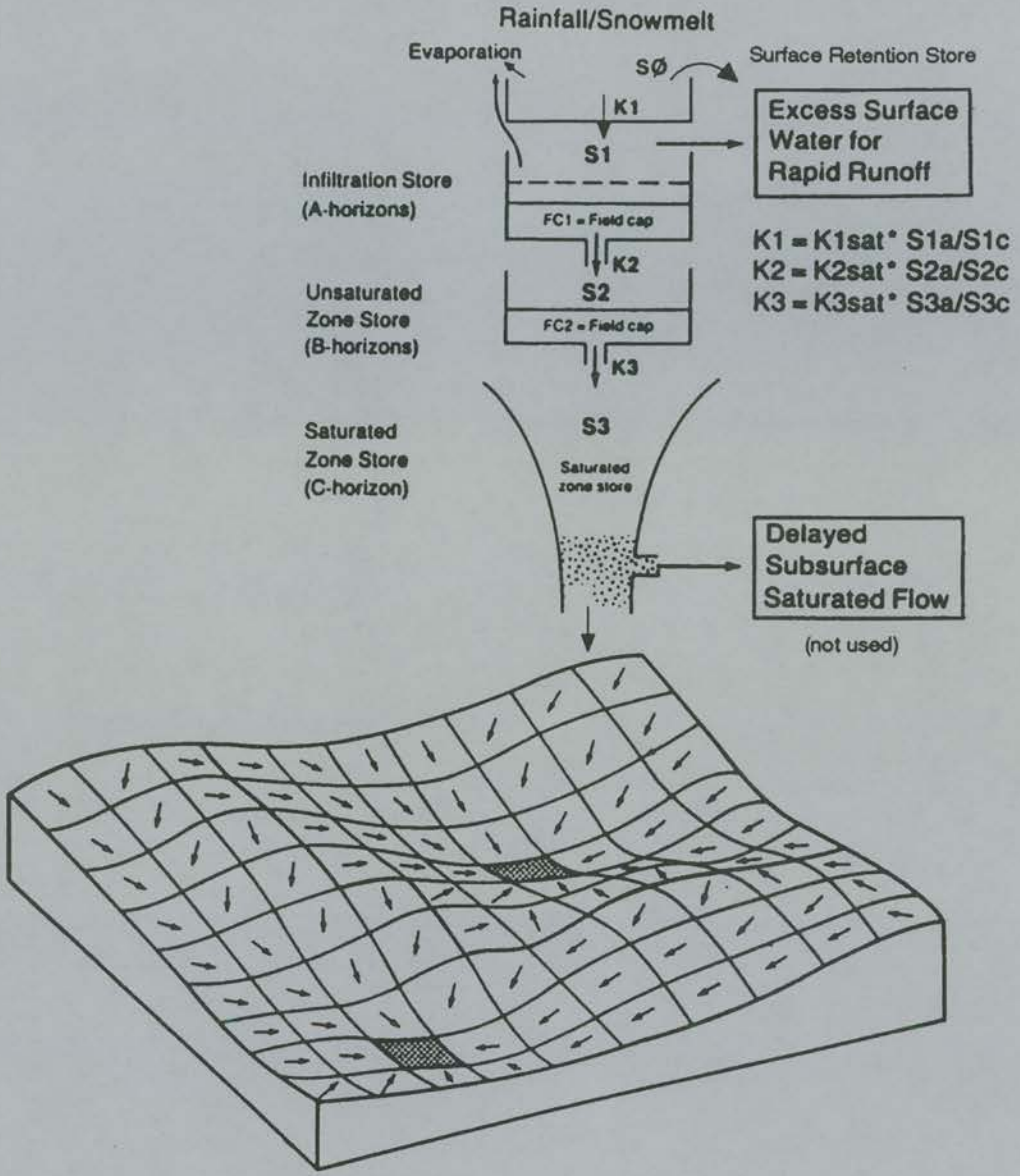
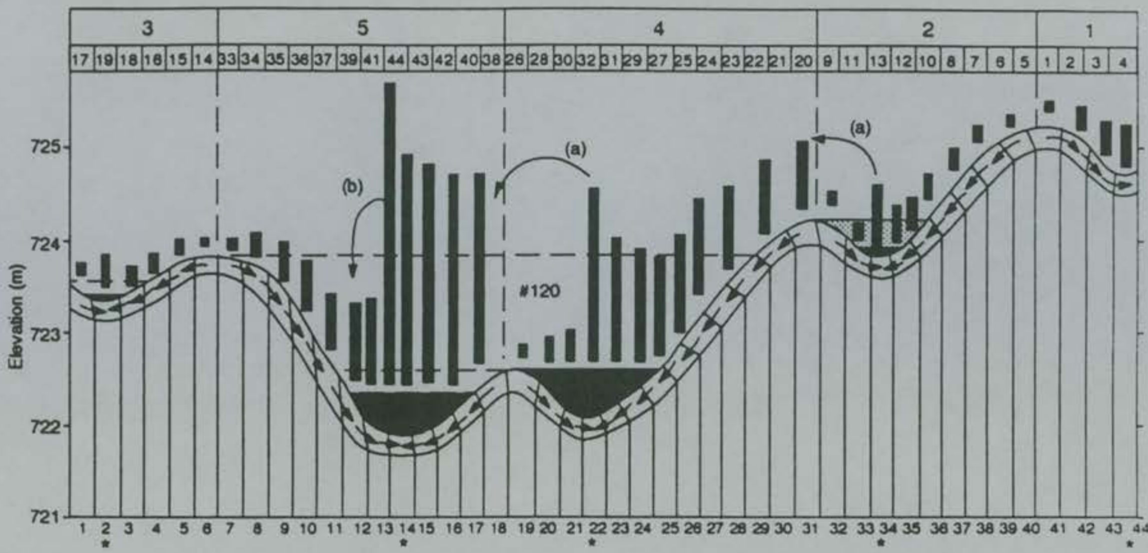


Figure 5.8 Experimental design - model development: procedures followed in designing and building the DISTHMOD distributed model.



SØ - surface retention store
S1 - infiltration store (A)
S2 - unsaturated zone store (B)
S3 - saturated zone store (C)
Knsat - saturated hydraulic conductivity of the nth store
K_n - drainage rate at actual (a) moisture content s_a for the nth store
s_{na} - actual moisture content (a) of store s_n at time t
s_{nc} - total storage capacity of store s_n
FCn - moisture content of store s_n at field capacity

Figure 5.9 Illustration of the conceptual model of cascading grid storage reservoirs adopted for the DISTHMOD model (modified after Beven et al., 1984)



Pond No.	Pond Row	Pond Col	Pond Elev	Vol. to Fill	Vol. in Pit	Pre Vol	Drains to Pit	Next Pit Up	Visited	Full	Final or Edge
1	10	44	724.6	undet.	0.0	0.0	edge	undet.	Y	N	Y
2	10	34	724.0	12.0	3.0	0.0	4	4	Y	Y	N
3	10	2	723.5	7.0	1.0	0.0	edge	undet.	Y	N	Y
4	10	22	722.2	20.0	20.0	0.0	5	120	Y	Y	N
5	10	14	722.0	30.0	20.0	0.0	4	120	Y	N	N
120 (=4+5)	10	14	722.0	100.0	20.0	50.0	3	3	N	N	N

- Processing is ordered by catchment. The catchment (1) with the highest elevation pour point is processed first, then all others in order of their pour point elevations.
- Within a catchment, processing is ordered by elevation along flow paths (ie. by upslope area) so that all upslope cells are processed and their runoff (or losses) computed before any given cell at a lower elevation is processed.
- At pit cell (starred) model checks Vol. in Pit plus runoff volume to see if it exceeds storage volume (Vol. to Fill) of depression.
- If NO, then model adds runoff volume to Vol. in Pit to compute new Vol. in Pit for that depression.
- If YES, runoff volume in excess of remaining storage capacity is determined and this volume is placed at:
  a) an overspill cell
  b) into Vol. in Pit of a higher order (subsuming) depression (ie. 120).

Figure 5.10 Illustration of the order in which grid cells are processed in the DISTHMOD model and of the procedures by which excess runoff accumulates in or escapes from depressions.

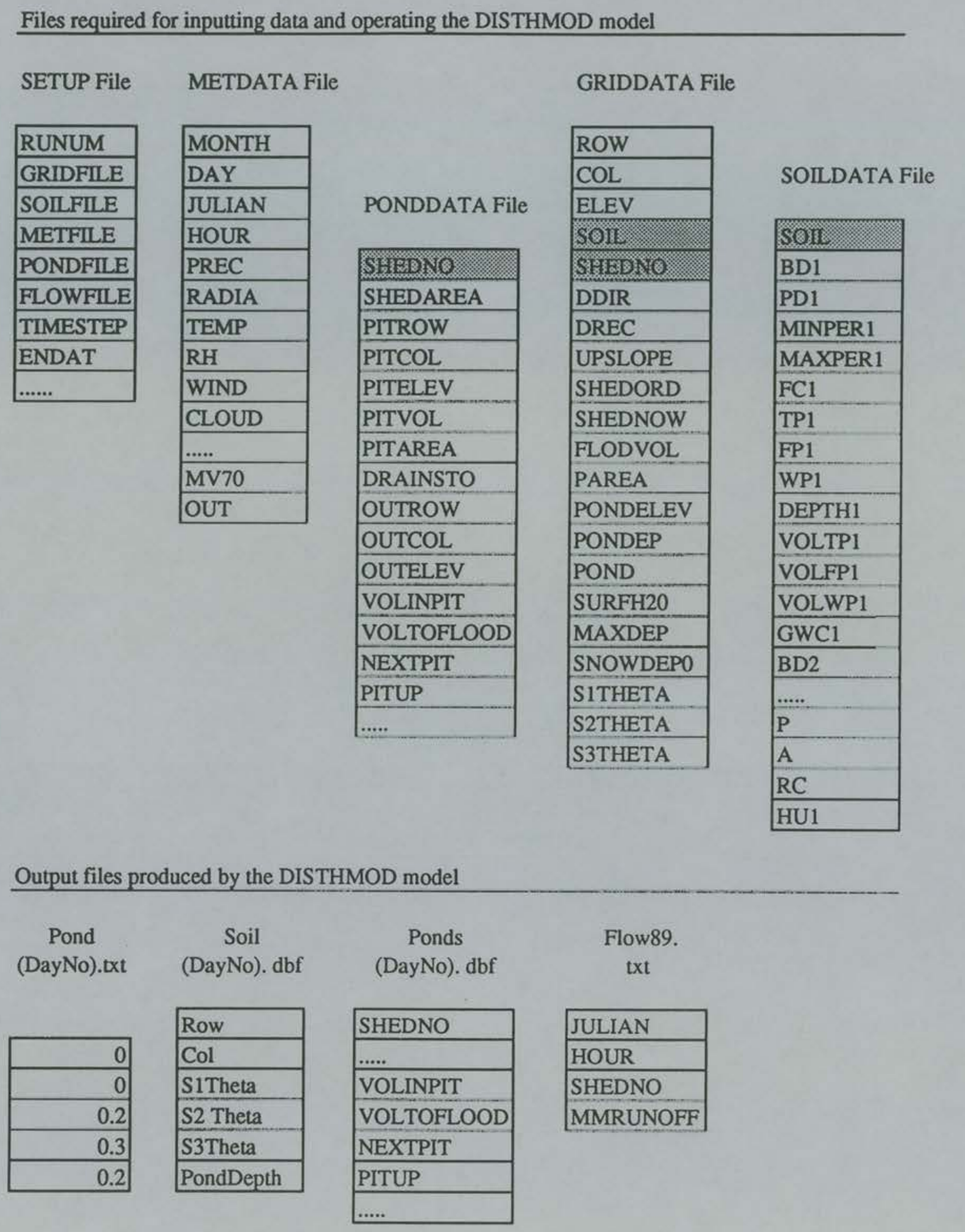


Figure 5.11 Illustration of the relational database model used to store and process data for DISTHMOD.

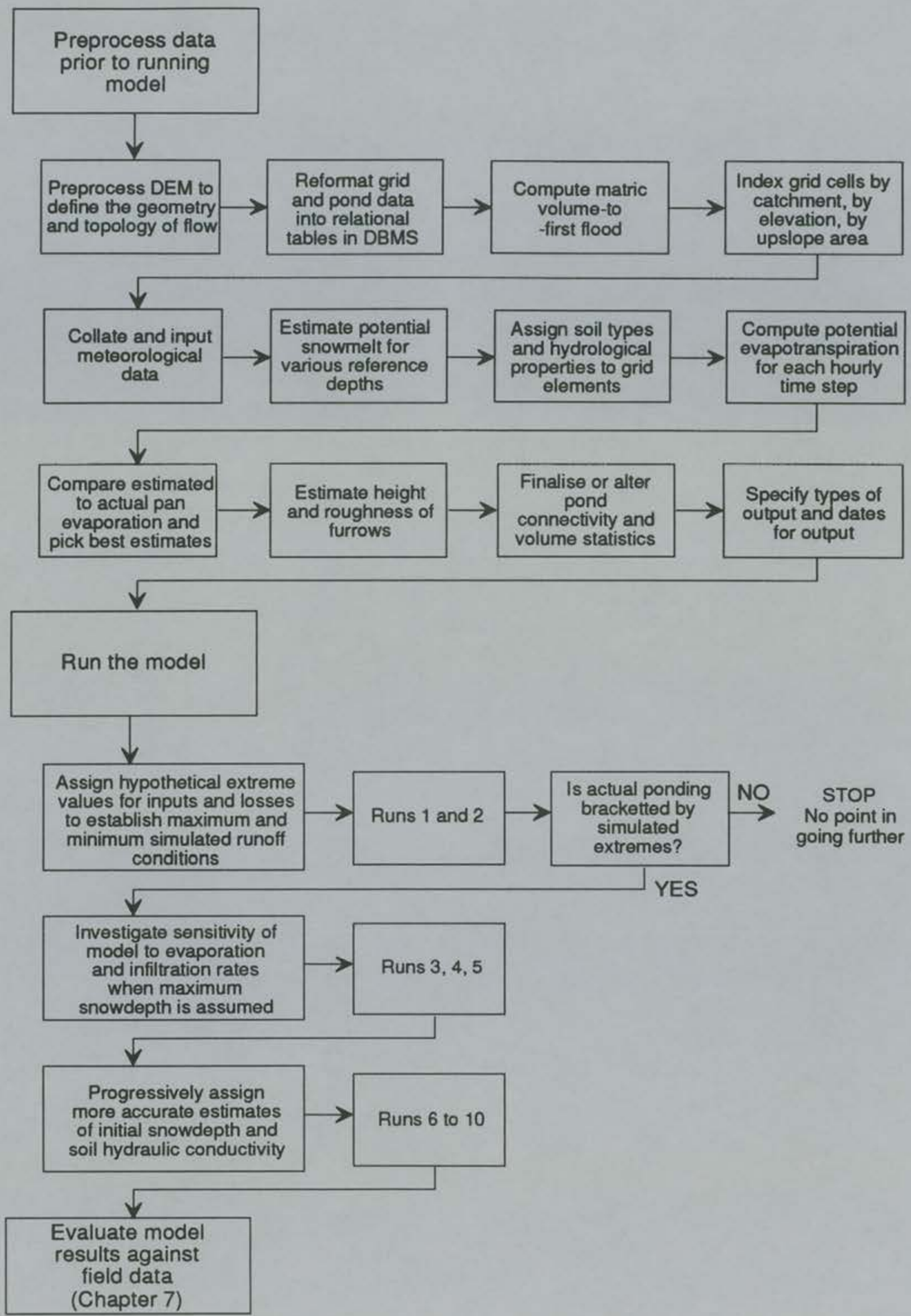
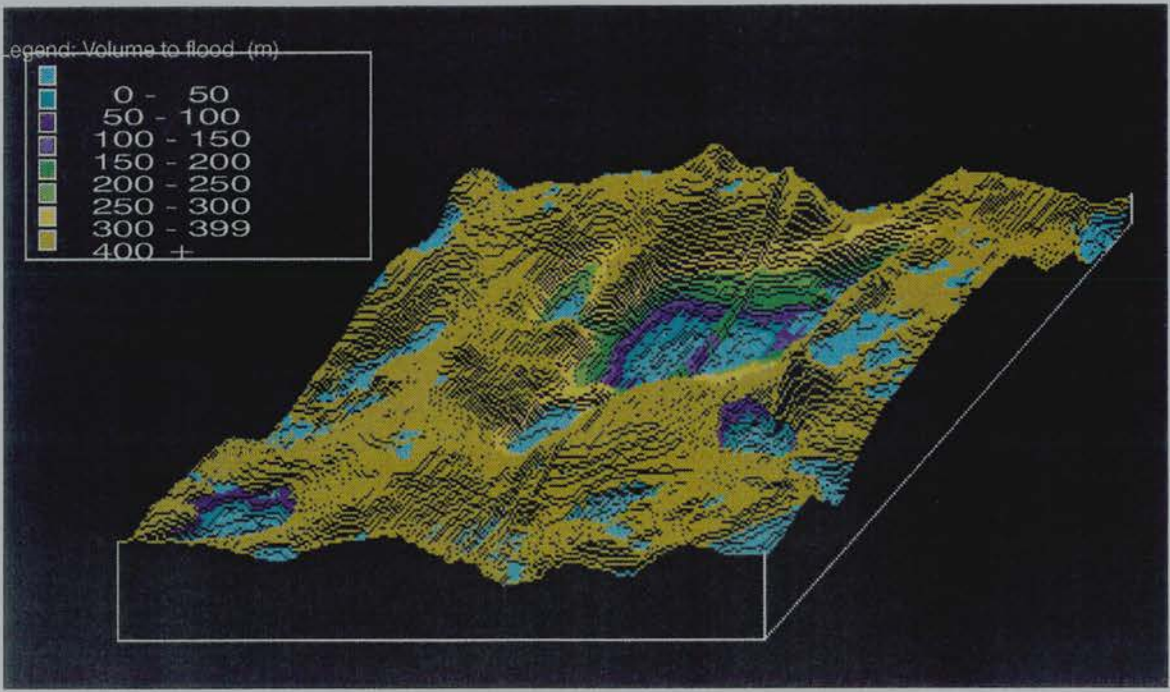


Figure 6.1 Experimental design - model application: procedures followed in applying the DISTHMOD distributed model to the Lunty site.



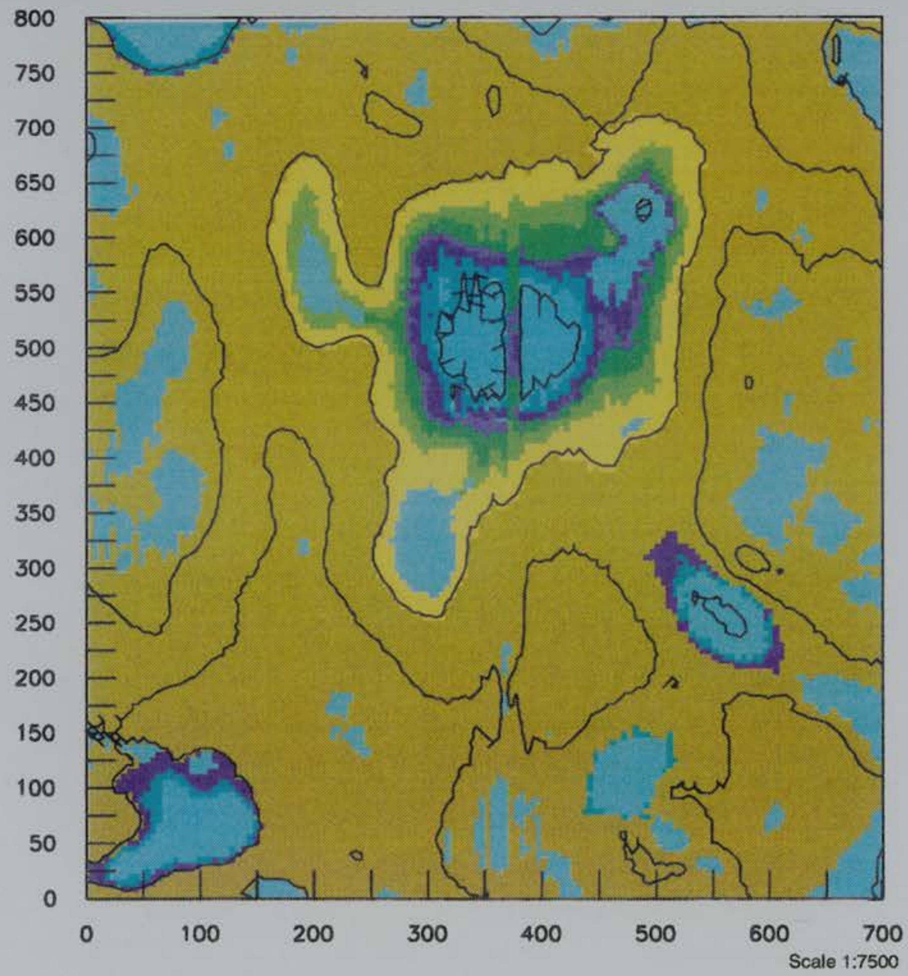


Figure 6.2 Computed volume-to-first-flood (FLODVOL) displayed draped over topography (top) and as a 2 dimensional grid map (bottom).

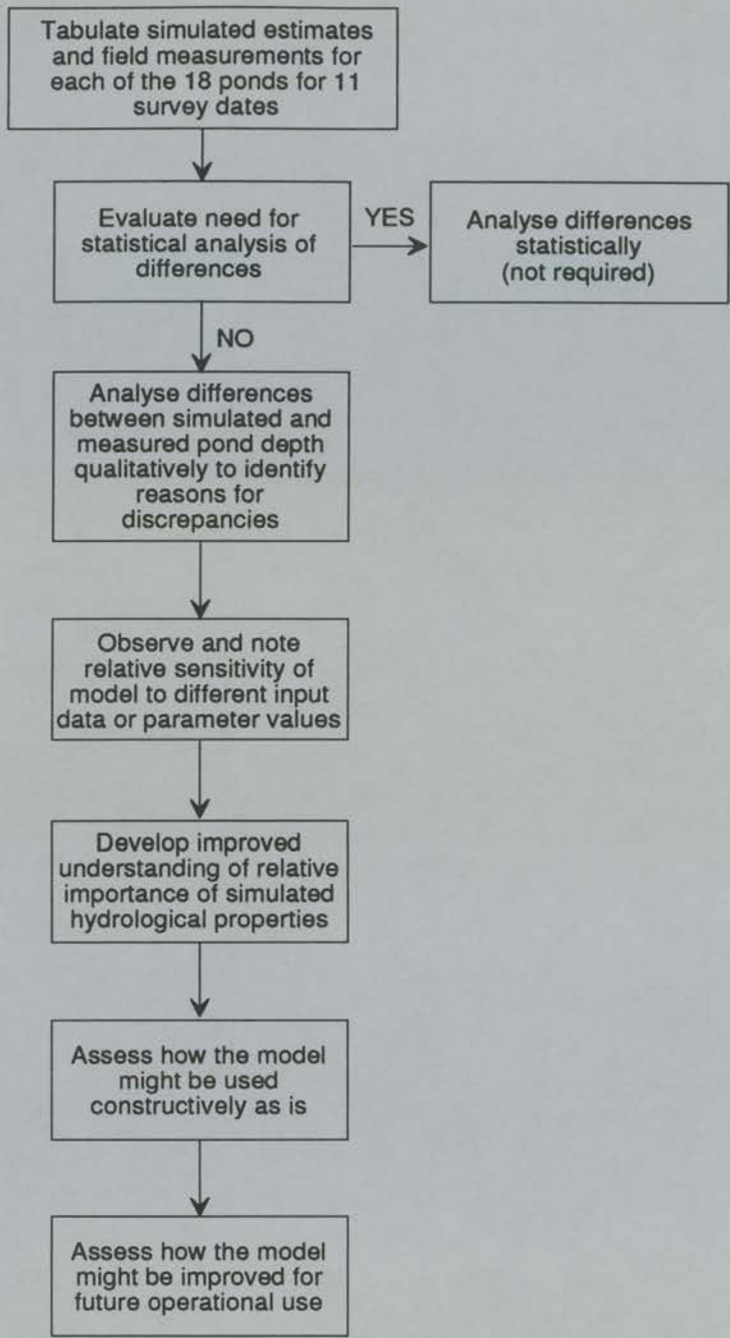
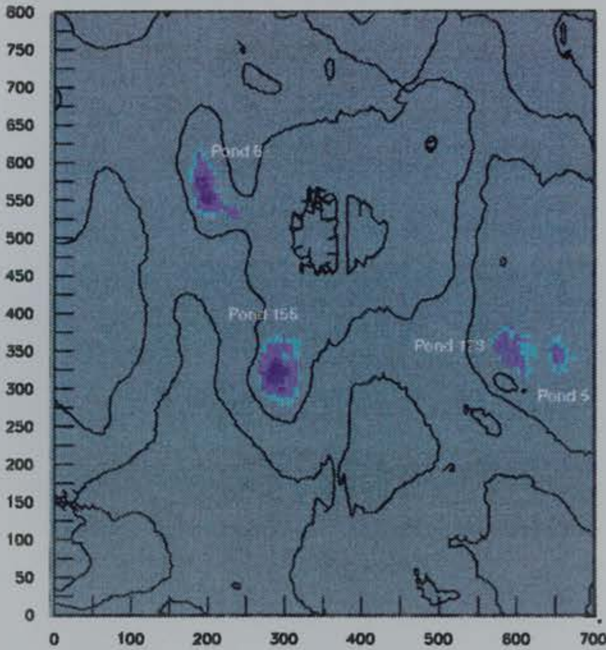
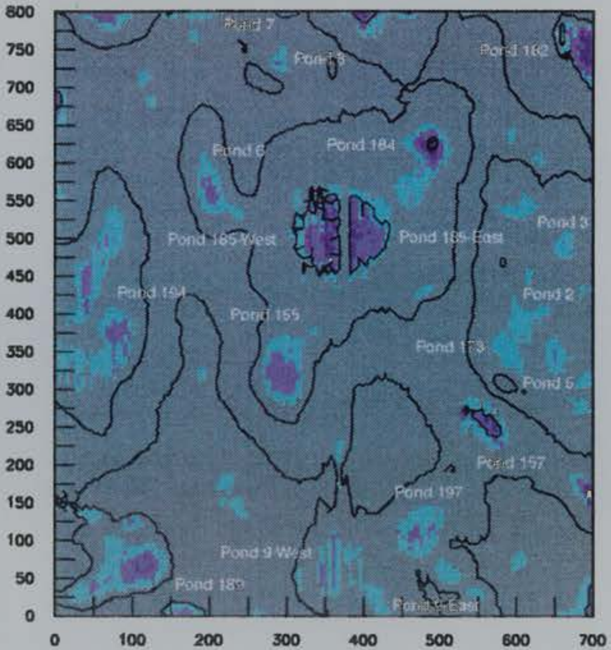


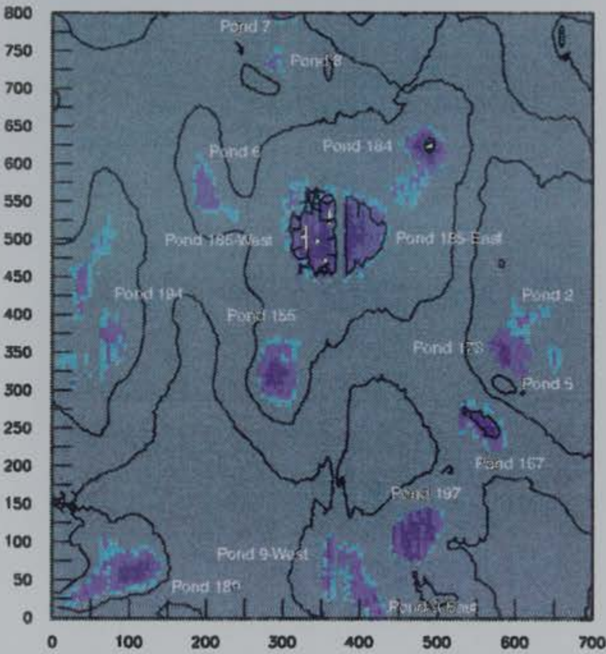
Figure 7.1 Experimental design - model evaluation: procedures followed in evaluating the performance and sensitivity of the DISTHMOD distributed model.



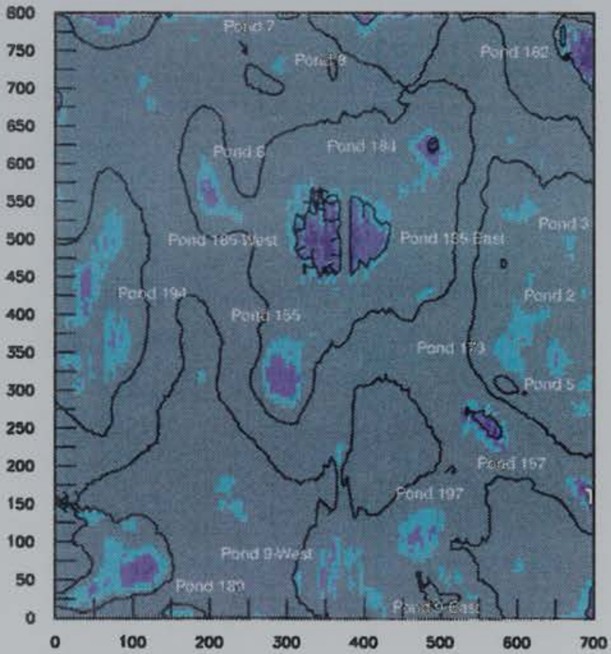
a) Extent of ponding surveyed on March 31, 1989



a) Extent of ponding simulated for March 31, 1989

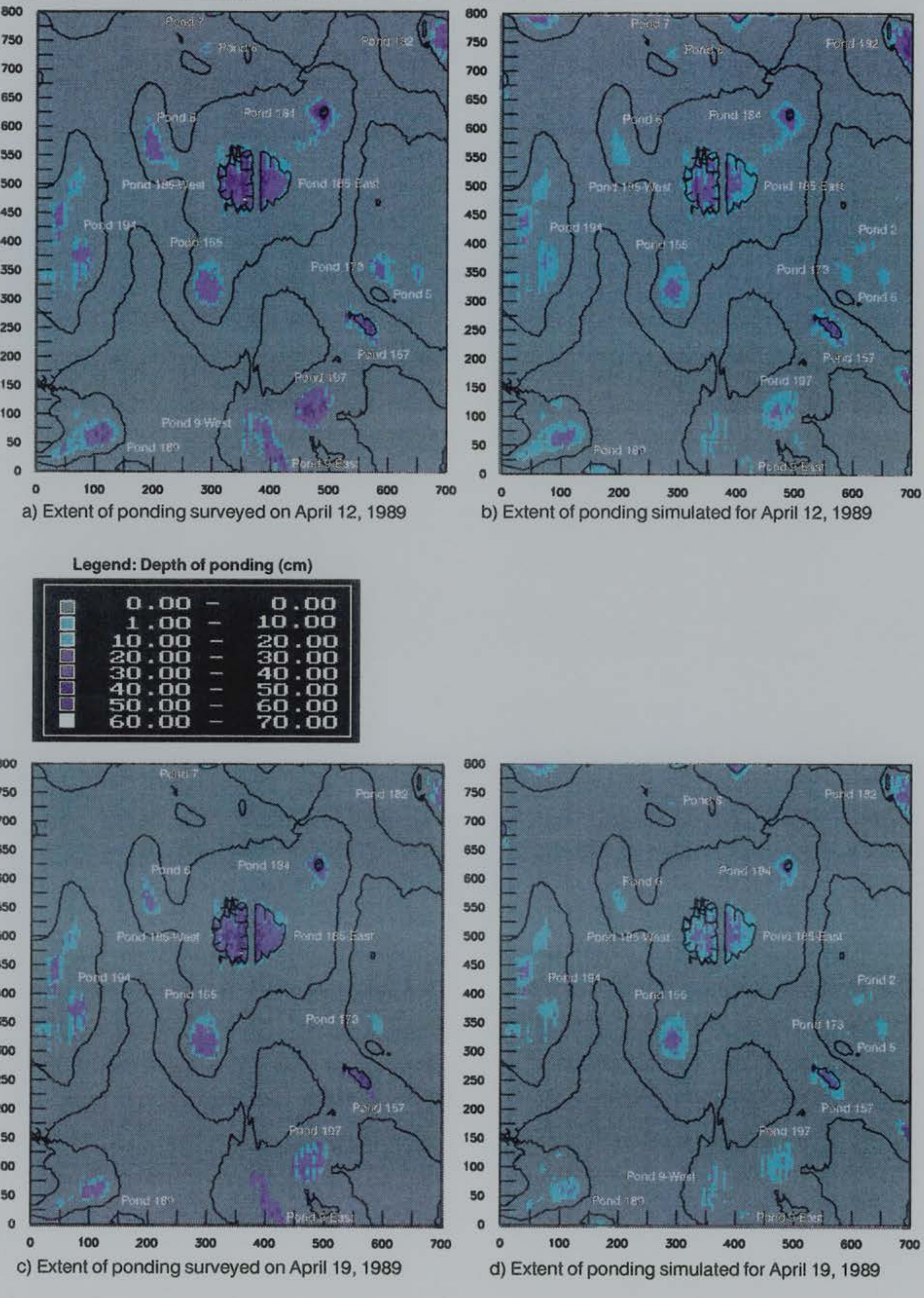


c) Extent of ponding surveyed on April 4, 1989



d) Extent of ponding simulated for April 4, 1989

Figure 7.2 Grid maps comparing the location, extent and depth of ponding determined by field surveys with simulated results from run 9 for March 31 & April 4, 1989.



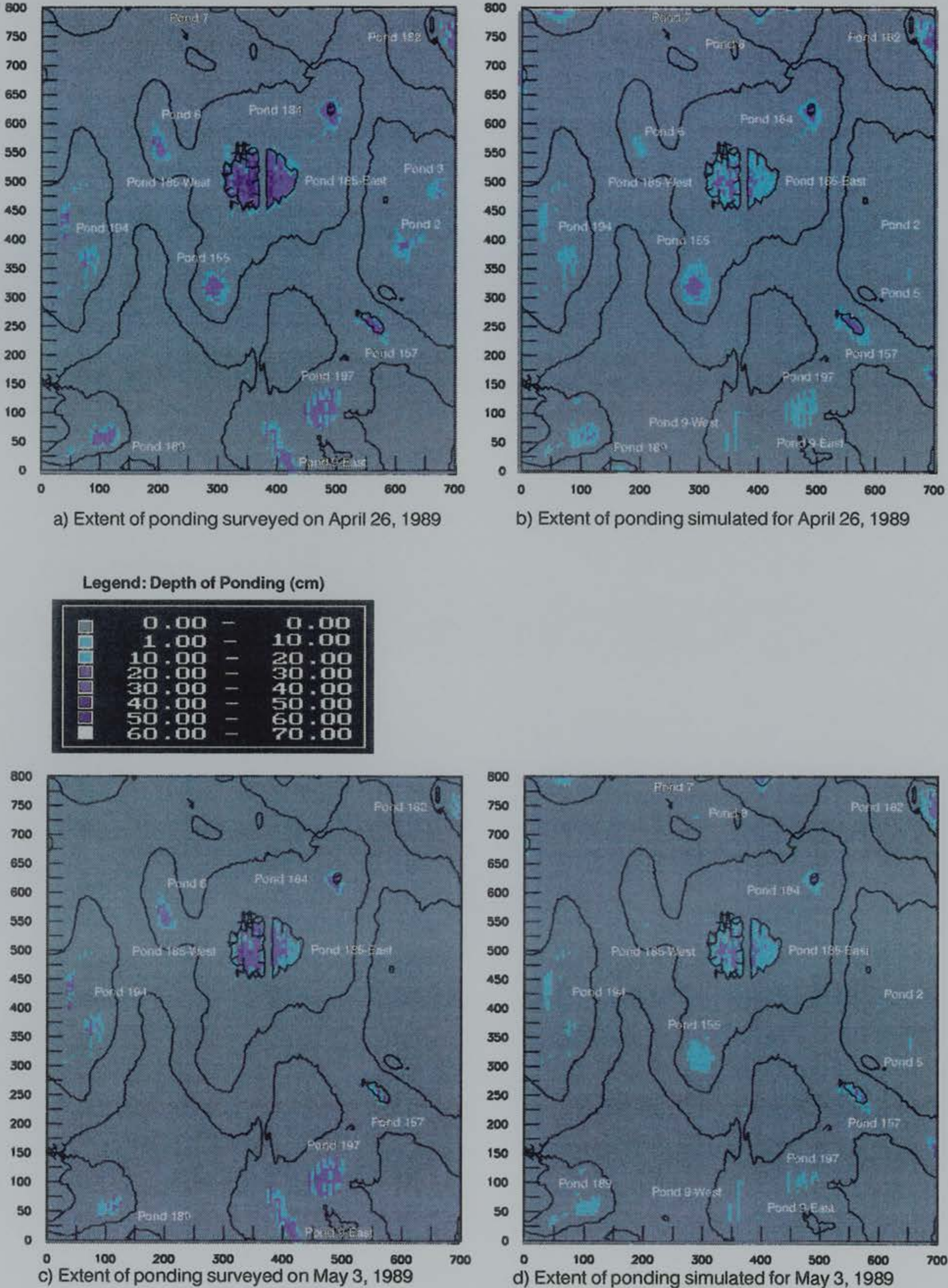
a) Extent of ponding surveyed on April 12, 1989

b) Extent of ponding simulated for April 12, 1989

c) Extent of ponding surveyed on April 19, 1989

d) Extent of ponding simulated for April 19, 1989

Figure 7.3 Grid maps comparing the location, extent and depth of ponding determined by field surveys with simulated results from run 9 for April 12 & 19, 1989.



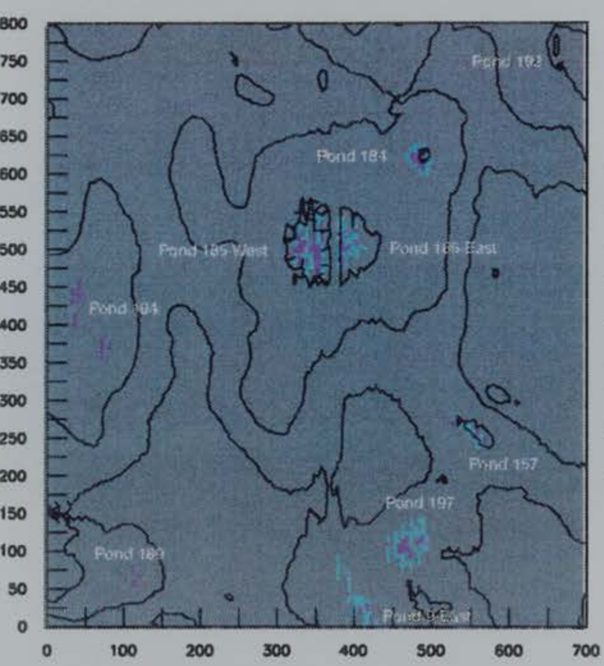
a) Extent of ponding surveyed on April 26, 1989

b) Extent of ponding simulated for April 26, 1989

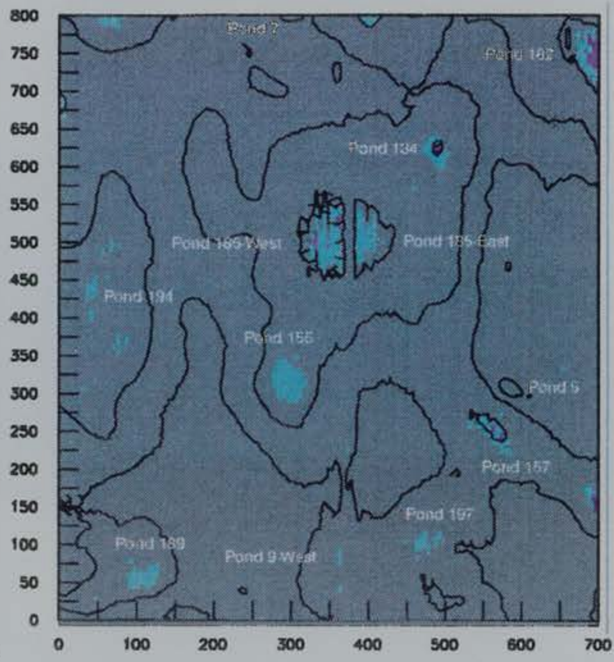
c) Extent of ponding surveyed on May 3, 1989

d) Extent of ponding simulated for May 3, 1989

Figure 7.4 Grid maps comparing the location, extent and depth of ponding determined by field surveys with simulated results from run 9 for April 26 & May 3, 1989.

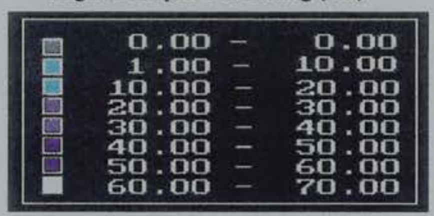


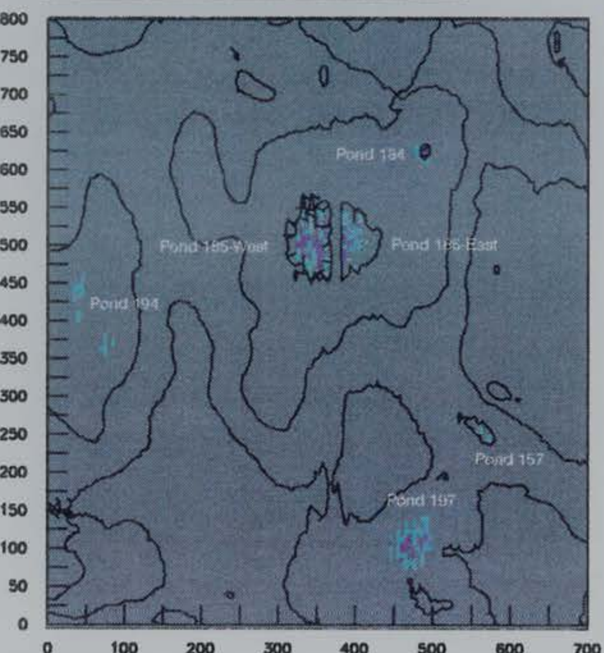
a) Extent of ponding surveyed on May 10, 1989



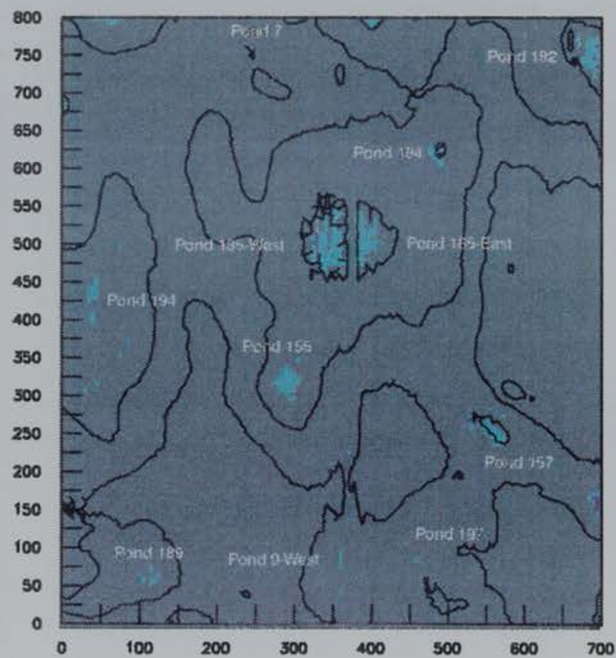
b) Extent of ponding simulated for May 10, 1989

Legend: Depth of Ponding (cm)



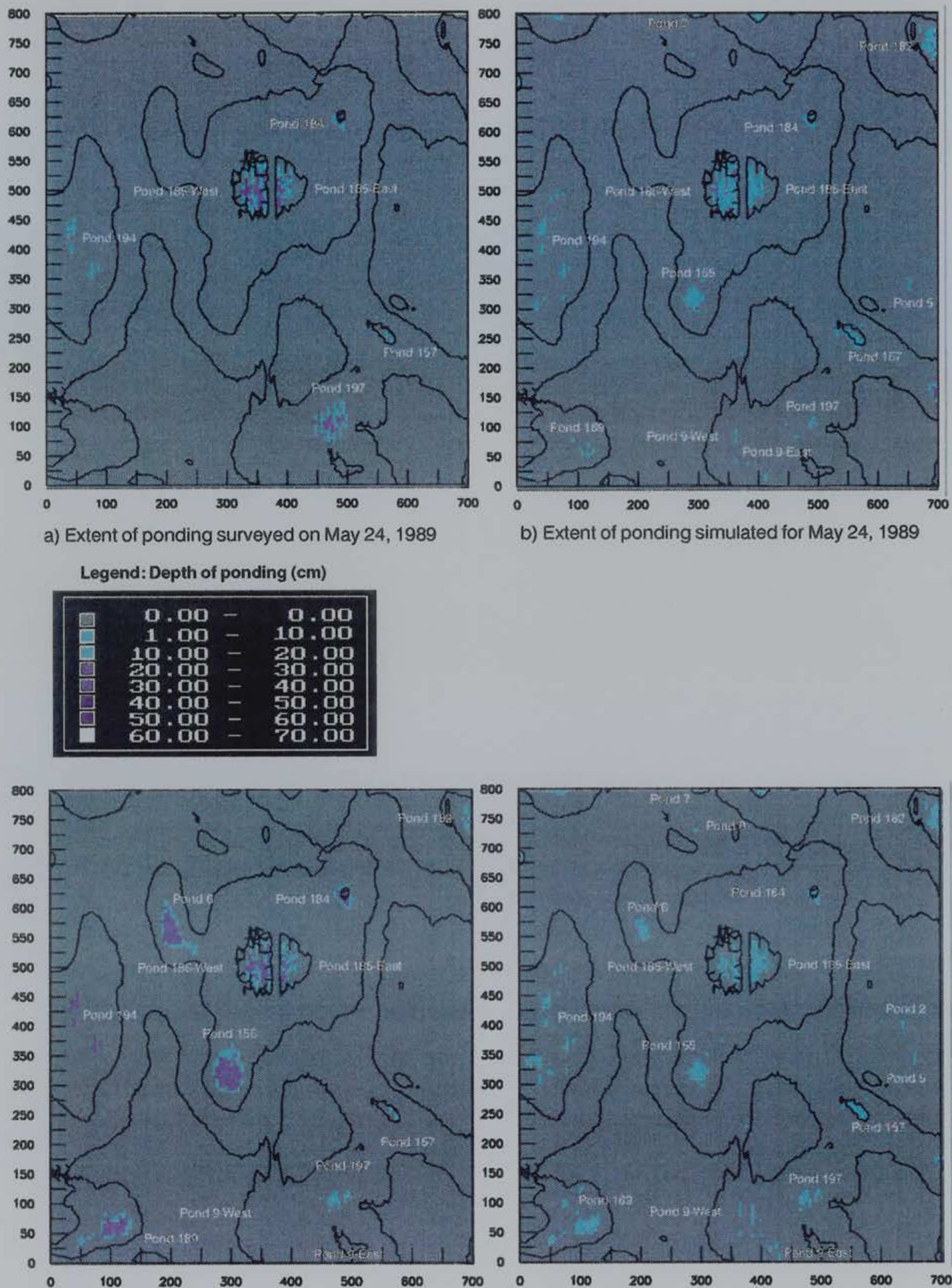


c) Extent of ponding surveyed on May 17, 1989



d) Extent of ponding simulated for May 17, 1989

Figure 7.5 Grid maps comparing the location, extent and depth of ponding determined by field surveys with simulated results from run 9 for May 10 & 17, 1989.



a) Extent of ponding surveyed on May 24, 1989

b) Extent of ponding simulated for May 24, 1989

c) Extent of ponding surveyed on July 4, 1989

d) Extent of ponding simulated for June 15, 1989

Figure 7.6 Grid maps comparing the location, extent and depth of ponding determined by field surveys with simulated results from run 9 for May 24 & June 15, 1989.

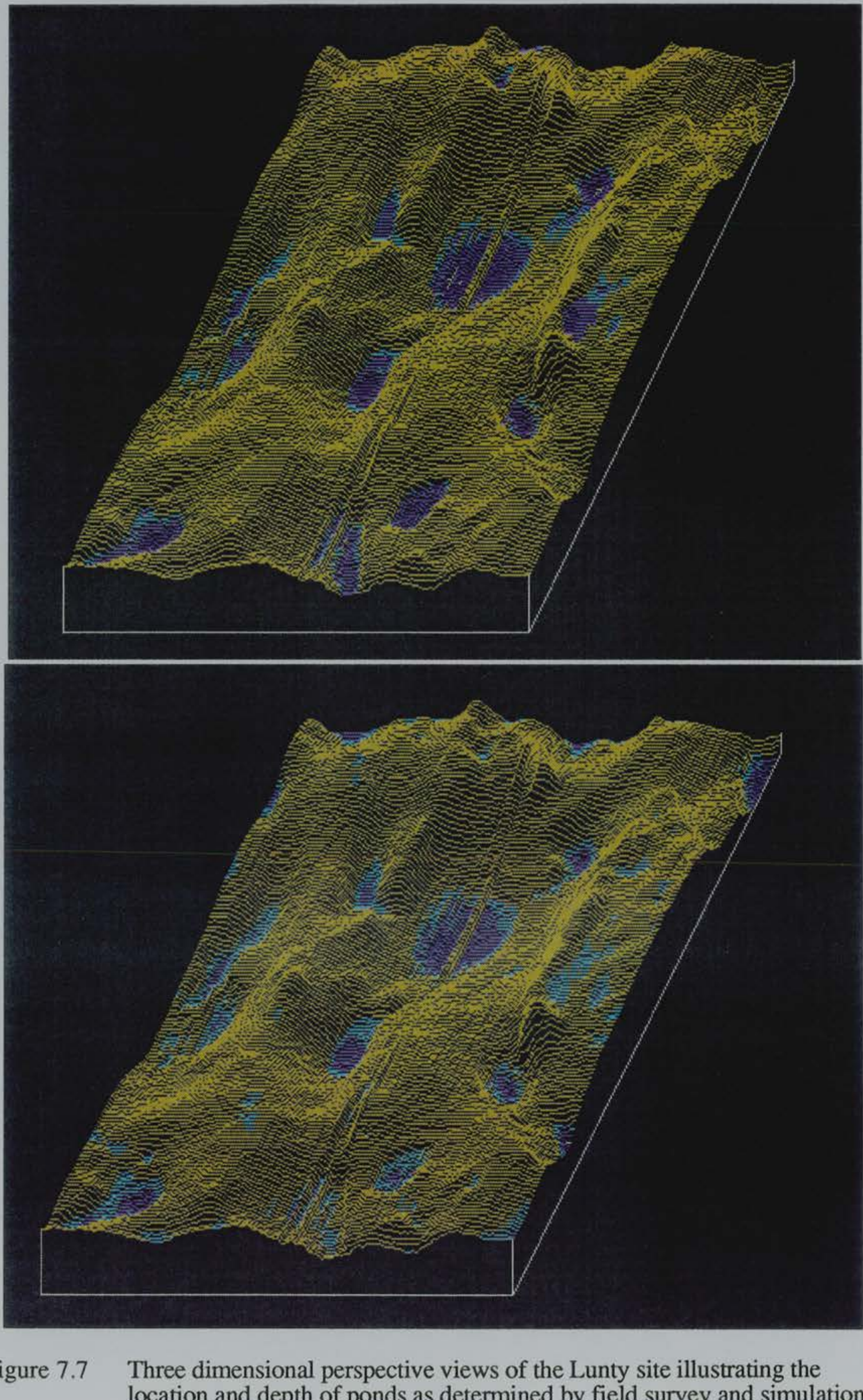
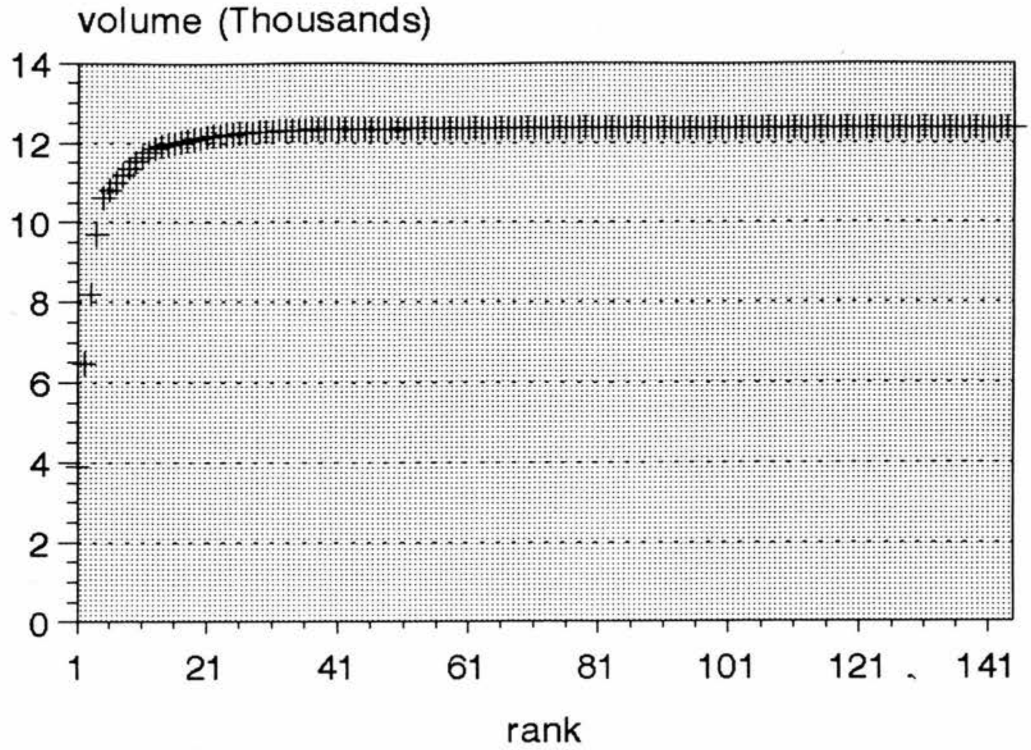
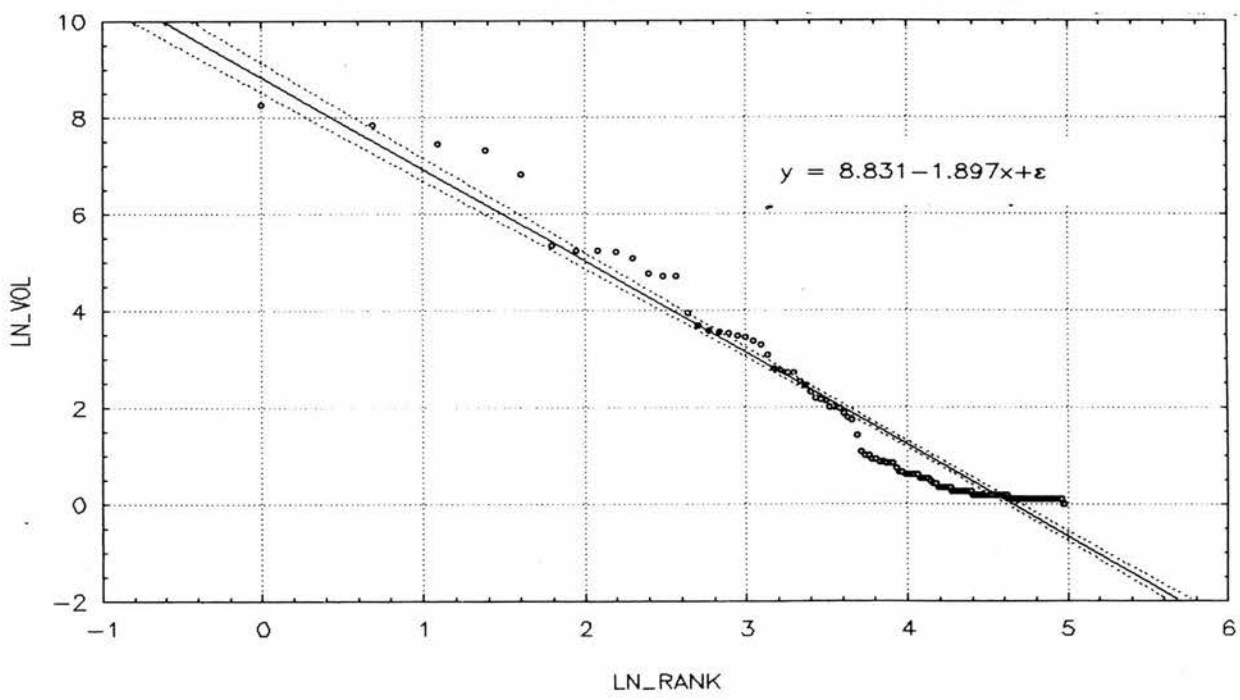


Figure 7.7 Three dimensional perspective views of the Lunty site illustrating the location and depth of ponds as determined by field survey and simulation run 9 for April 4, 1989.



a) Frequency distribution plot of pit volume versus pit rank illustrates how the few largest pits contain most of the water stored in the landscape (plot courtesy of P. A. Burrough, personal communication, 1994)



b) Linearity of the plot of log rank versus log volume for pits suggests that the pit volumes are fractal over 3 orders of magnitude and are illustrative of Zipf's law (plot courtesy of P. A. Burrough, personal communication, 1994)

Figure 8.1 Illustration of the probability distribution of depressions by rank and volume.

TABLES

Table 3.1 Identification and recognition of contributions made to the field program.

Generic Activity	Specific Activity	RM	MH	GJ	BS	Others
Site selection	List options and select site	X				
	Secure land owner permission		X	X		
Soil mapping	Survey grid point locations		X	X		
	Conduct grid soil survey	X	X			
	Produce digital soil polygon map	X				J. Lutz
Site characterisation	Select sites to sample/monitor	X	X			M. Trudell
	Describe/sample soil profiles	X	X			
	Collect cores for BD & TP	X	X			
	Do lab analysis of soil samples					ARC Lab
	Collate & tabulate lab data	X				
	Field measurement of K_{sat}	X	X			
	Produce soil description forms	X				S. A-Smith
Soil moisture instrumentation & monitoring	Install TDR & gypsum blocks	X	X			
	Monitor & record moisture data		X	X		
	Compile, enter, edit & graph data	X				
Meteorological instrumentation & monitoring	Install & maintain Lunty met site		X	X		
	Provide data from alternate site				X	
	Collate, convert, edit & graph data	X			X	M. Fawcett
Obtain & process DEM	Arrange air photos & survey control			X		M. Trudell
	Produce digital elevation data file					AFLW
	Reformat DEM & compute derivitives	X				
	Use DEM to compute flow topology	X				
Snow survey	Conduct snow pack survey at sites		X	X		
	Build & use regression for snow depth	X				
Pond survey	Stake pond location & extent		X	X		
	Survey location & elevation of stakes		X	X		
	Compile, enter, check & edit data	X				
	Write & apply program to map ponds	X				

RM = R. MacMillan; MH = M. Huemmert; GJ = G. Jean; BS = B. Sawyer; AFLW = Alberta Forestry, Lands and Wildlife; S. A-Smith = S. Andrews-Smith; ARC Lab = A. Swartzer, J. Beres, D. Reid, R. Faught, S. Abboud.

Table 3.2 Soil and landform observations recorded at grid survey locations.

Observation	Units	Description or Explaination
Site No.	n/a	Sequential identification number for site
Row (y)	40 m	Row number starting at top (N) of quarter
Col (x)	40 m	Column number starting at W side of quarter
Slope %	percent	Percent slope gradient at site
Slope pos	code	Relative slope position at site
Surface shape	code	Shape of surface st site (convex/concave)
A-horizon type	code	Type of surface (A) horizon
A-horizon thick	cm	Thickness of surface (A) horizon in cm
A-horizon text	code	Texture of surface (A) horizon
Ae thick	cm	Thickness of eluvial A horizon (if present)
B-horizon type	code	Type of sub-surface (B) horizon
B-horizon depth to	cm	Depth to top of B horizon in cm
B-horizon text	code	Texture of subsurface (B) horizon
B-horizon structure	code	Structure of subsurface (B) horizon
C-horizon type	code	Type of subsoil (C) horizon
C-horizon depth to	cm	Depth to subsoil (C) horizon in cm
C-horizon text	code	Texture of subsoil (C) horizon
Depth to impede	cm	Depth to hard or impeding subsoil horizon (if any) in cm
Depth to roots	cm	Depth of penetration of roots in cm
Depth to mottles	cm	Depth to first appearance of mottling in cm
Depth to lime	cm	Depth to first indication of lime ($CaCO_3$) in cm
Depth to salts	cm	Depth to first appearance of soluble salts in cm
Drain class	code	Soil drainage class (ECSS, 1983)
PM type	code	Type of parent geological material
Subgroup class	code	Soil classification at the Subgroup level (ECSS, 1983)
Series code	code	Three letter soil series code (ie. KLM)
Map Unit	code	Map unit label of most appropriate soil map unit for site
Comments	text	Free form text comments about site

Table 3.3 Location of transect sample sites and identification of analyses completed for each site.

Site No.	Tran No.	North (m)	East (m)	Grid Row	Grid Col	Grid Elev	Survey Elev	Site Desc	Soil Samp	Bulk Dens	Field Ksat	TDR & Gyp
175	1	460	595	68	119	727.4	727.997	Y	Y	Y	Y	Y
176	1	460	555	68	111	727.0	727.052	Y	Y	Y	Y	Y
177	1	460	535	68	107	724.9	725.021	Y	Y	Y	Y	Y
179	1	460	515	68	103	723.8	723.907	Y	Y	Y	Y	Y
180	1	460	505	68	101	723.5	723.491	Y	Y	Y	Y	Y
181	1	460	495	68	99	723.3	723.351	Y	Y	Y	Y	Y
191	1	480	315	64	63	722.0	721.877	N	N	Y	N	Y
192	1	466	275	66	55	723.1	723.027	Y	Y	Y	Y	Y
193	1	460	175	68	35	725.3	725.273	Y	Y	Y	Y	Y
194	1	380	95	84	19	722.8	722.676	N	N	N	N	Y
200	1	460	460	68	92	723.3	723.098	Y	Y	Y	Y	Y
201	1	460	455	68	91	723.2	723.118	Y	Y	Y	Y	Y
202	1	459	440	68	88	722.8	722.683	Y	Y	Y	Y	Y
203	1	486	435	62	87	722.1	722.088	Y	Y	Y	Y	Y
207	1	480	635	64	127	726.8	unknown	Y	Y	Y	Y	Y
211	1	460	255	68	51	723.9	unknown	Y	Y	Y	Y	Y
154	2	0	5	160	1	726.7	726.479	Y	Y	Y	Y	Y
155	2	325	290	95	58	722.9	722.790	N	N	Y	N	Y
182	2	720	715	16	143	0.0	721.291	N	N	N	N	Y
183	2	700	675	20	135	722.9	722.932	N	N	Y	Y	Y
184	2	620	495	36	99	721.9	721.991	N	N	N	N	Y
188	2	660	575	28	115	725.0	725.096	N	N	Y	Y	Y
189	2	60	115	148	23	725.1	725.058	N	N	Y	Y	Y
190	2	200	215	120	43	727.4	727.491	Y	Y	Y	Y	Y
204	2	85	140	143	28	725.4	725.472	Y	Y	Y	Y	Y
205	2	115	170	137	34	726.7	726.742	Y	Y	Y	Y	Y
300	2	680	625	24	125	723.4	unknown	N	N	Y	Y	Y

Table 3.4 Laboratory methods used to characterise soils at the Lunty site.

Method of Analysis	**Horizons Analysed**			**Description of Method and Reference**
	A	**B**	**C**	
pH (H_2O)	X	X	X	pH in 1:1 water paste (method 3.14 in McKeague, 1978).
pH ($CaCl_2$)	X	X	X	pH in 1:2 soil:0.1 M $CaCl_2$ (Richards, 1954).
Total Carbon	X	X		Dry combustion in a resistance furnace (Leco CR12 Total Carbon Instrument) (Tabatabai and Bremmer, 1970).
$CaCO_3$ equivalent		*	X	Acid dissolution and measurement by the Calcimeter method (Bascomb, 1961).
Cation Exchange Capacity Exchangeable cations (Ca, Mg, Na, K)	X	X		Displacement of ions by 1 M ammonium acetate (NH_4OAc) (pH 7) and measurement of NH_4 by the Kjeldahl method. Ions by ICP-AES (method 5A8 in USDA, 1984).
Saturated Paste Extracts, Electrical Conductivity, and Soluble ions	X	X	X	Paste by USDA, ions by ICP-AES and FIA (USDA, 1954).
Particle size analysis	X	X	X	Simplified Hydrometer method (Gee and Bouder, 1979).

* B-horizons with visible effervescence or visible salts analysed for $CaCO_3$

Table 3.5 Types and frequency of meteorological observations recorded at the Lunty site.

Type of Observation	Units	Sensing Instrument	Recording Instrument	Observation Frequency	Period of Observation
Rainfall	mm	Auto siphoning Hellman rainfall recorder	Meteograph M701 7 day mechanical strip chart recorder	1 hour scale over 7 day strip	April 5, 1989 to Oct.31, 1989
Temperature	deg C	Thermister	Meteograph M701 7 day mechanical strip chart recorder	2 hour scale over 7 day strip	April 5, 1989 to Oct.31, 1989
Solar Radiation	g-cal cm^{-2} min^{-1}	Belfast Inst. Co. model 5-3850 pyranograph	Meteograph M701 7 day mechanical strip chart recorder	2 hour scale over 7 day strip	April 5, 1989 to Oct. 31, 1989
Relative Humidity	percent	Calibrated horse hair	Meteograph M701 7 day mechanical strip chart recorder	2 hour scale over 7 day strip	April 5, 1989 to Oct.31, 1989
Wind Speed	m sec^{-1}	R M Young model no. 5103 anemometer	Omnidata Easylogger model no. EL824	5 min samples averaged to 1 hour	March 22, 1989 to Oct. 31, 1989
Pan Evaporation	mm cumulative	Sierra/Misco Inc. model no. 3005 class A evaporation pan	Recorded manually	approximately 7 days (weekly)	March 31, 1989 to Oct. 31, 1989
Soil Temperature	deg C	Weather Moisture Corp. model T601 2-point thermograph	Meteograph M710 7 day mechanical strip chart recorder	2 hours scale over 7 day strip	April 5, 1989 to Oct.31, 1989

Note: All wind speed data and data for the period March 22, 1989 to April 5, 1989 were obtained from the Henderson (HN) research site (53° 4 N', 111° 56' W), also operated by the Alberta Research Council (Howitt, 1991). This site utilised digital devices (Omnidata Easylogger Model No. EL824) for recording meteorological data. The digital recorder was able to operate under conditions of greater snowfall and lower temperature and consequently was set up and recording data earlier in the spring that the mechanical devices in use at the Lunty site.

Table 3.6 Summary of cultivation and cropping activities at the Lunty site for 1988/89.

Cultivation / Cropping Activity	Field 1	Field 2	Field 3
Condition of the field in fall 1988	stubble	fallow	stubble
Date of first cultivation in spring, 1989	May 5	May 6	May 7
Date of second cultivation in spring, 1989	none	none	none
Date of crop seeding in spring, 1989	May 21	May 22	May 23
Type of crop seeded in spring, 1989	wheat	barley	canola
Date of crop emergence in spring, 1989	June 8	June 9	June 8
Date of harvest in fall, 1989	Sept 19	Sept 20	Sept 21
Type of post harvest operation in fall, 1989	none	none	none

Table 3.7 Comparison of precipitation and temperature data from the Lunty site for Spring, 1989 to the 1989 and 1950-1981 30 year long term average (LTA) values for the nearby Forestburg Plant Site AES station.

	Precipitation (mm)					
	March	April	May	June	April - June Total	Annual Total
Lunty site, 1989	n/a	7.0	19.4	93.2	119.6	n/a
Forestburg AES, 1989	3.2	13.5	34.3	96.6	144.4	420.0
Forestburg AES, LTA	11.8	19.4	37.6	78.9	135.9	384.8

	Temperature (deg C)					
	March Ave.	April Ave.	May Ave.	June Ave.	April - June Average	Annual Average
Lunty site, 1989	n/a	3.5	8.9	14.0	8.8	n/a
Forestburg AES, 1989	-7.4	5.8	11.3	16.4	11.2	4.3
Forestburg AES, LTA	-5.8	3.7	11.0	15.2	10.0	3.0

Source: Climate of Alberta. Alberta Environment (1989).

Table 3.8 Classification of the major soil series encountered at the Lunty site.

Soil Series Name (Code)	Canadian Classification to Level of Subgroup (ECSS, 1987b)	American Classification to Level of Subgroup (Soil Survey Staff, 1990)
Elnora (EOR)	Orthic Black (O.BL)	Udic Haploboroll
Sedgewick (SGK)	Eluviated Black (E.BL)	Boralfic Udic Argiboroll
Lanfine (LFN)	Gleyed Eluviated Black (GLE.BL)	Aquic Argiboroll
Heisler (HER)	Solonetzic Black (SZ.BL)	Abruptic Udic Argiboroll
Daysland (DYD)	Black Solod (BL.SO)	Typic Natralboll
Killam (KLM)	Black Solodized Solonetz (BL.SS)	Glossic Udic Natriboroll
Foreman (FMN)	Solonetzic Luvic Gleysol (SZ.LG)	Typic Natraquoll
Cordel (COR)	Humic Luvic Gleysol (HU.LG)	Abruptic Argiaquoll
Haight (HGT)	Orthic Humic Gleysol (O.HG)	Typic Haplaquoll

Table 3.9 Legend for polygonal soil map of the Lunty site.

Map Unit No.	Map Unit Symbol	Soil Classification Composition: Soil Subgroup	Soil Series	Estimated Proportion	Non-Technical Description of the Soil Composition of the Map Unit	Description of the Landscape Position Occupied by the Unit	Slope Percent
1	COR1/1	HU.LG O.HG SZ.LG	COR HGT FMN	60-80% 0-15% 0-15%	Dominantly poorly drained, non-saline, non-sodic, strongly leached, strongly gleyed soil; with inclusions of non-saline, non-sodic, non-leached strongly gleyed soil; and saline, sodic, moderately gleyed soil displaying a sub-surface hardpan layer (Bntg).	Concave, ponded depressions	< 0.5%
2	COR1/2	HU.LG GLE.BL O.HG SZ.LG	COR LFN HGT FMN	50-70% 0-15% 0-15% 0-15%	Dominantly poorly drained, non-saline, non-sodic, deeply leached, strongly gleyed soil; with inclusions of slightly better drained, non-saline, weakly to strongly gleyed soil with no sub-surface hardpan layer; and some poorly drained, saline, sodic soil with a sub-surface hardpan layer.	Ponded depressions with minor knolls & ridges	0.5 - 2%
3	COR1/3	HU.LG GLE.BL SZ.LG	COR LFN FMN	50-70% 30-50% 0-15%	Dominantly poorly drained, non-saline, non-sodic, deeply leached, strongly gleyed soil; with significant amounts of slightly better drained, non-saline, non-sodic, moderately leached, weakly gleyed soil and minor inclusions of saline, sodic, strongly gleyed soil with a sub-surface hardpan layer.	Located on sloping rims of permanently ponded depressions	2 - 5%
4	FMN1/2	SZ.LG GLBL.SS HU.LG	FMN KLM/g COR	50-80% 0-15% 0-15%	Dominantly poorly drained, saline and sodic, strongly gleyed soil; with inclusions of slightly better drained, gleyed and sodic soil with a strongly developed sub-surface hardpan layer; and non-saline, non-sodic, deeply leached, strongly gleyed soil with no sub-surface hardpan layer.	Nearly level, slightly elevated terraces surronding depressions	0.5 - 2%
5	FMN1/3	SZ.LG GLBL.SS HU.LG	FMN KLM/g COR	50-80% 15-30% 0-15%	Dominantly poorly drained, saline and sodic, strongly gleyed soil with a dense sub-surface hardpan layer; with significant amounts of slightly better drained, gleyed and sodic soil with a strongly developed sub-surface hardpan layer; and minor inclusions of non-saline, non-sodic, strongly gleyed soil with no sub-surface hardpan layer.	Gently sloping lower to toe slopes surrounding local depressions	2 - 5%
6	KLM1/2	GLBL.SS SZ.LG GLR.BLsa	KLM/g FMN N/A	50-70% 15-40% 0-15%	Dominantly moderately to imperfectly drained, weakly gleyed, saline and sodic soil with a well developed sub-surface hardpan layer (Bnt); with significant amounts of poorly drained, saline and sodic, strongly gleyed soil with a dense clayey sub-surface hardpan layer; and inclusions of imperfectly drained saline and sodic soil lacking a well developed hardpan horizon.	Nearly level to gently sloping lower and toe slopes leading to local depressions	0.5 - 2%
7	KLM1/3	BL.SS BL.SO O.BL	KLM DYD EOR	50-80% 15-30% 0-15%	Dominantly moderately well drained, sodic soil with a well developed sub-surface hardpan layer (Bnt) and weak to moderate sub-soil salinity; with significant amounts of moderately well to well drained, sodic soil with a less well developed hardpan layer and weak sub-soil salinity; and inclusions of well drained, non-saline, non-sodic black soil with no hardpan horizon.	Very gently sloping upper to lower slopes leading to local depressions.	2 - 5%
8	DYD1/2	BL.SO BL.SS O.BL	DYD KLM EOR	50-80% 15-40% 0-15%	Dominantly well to moderately well drained, sodic soil with a weakly expressed sub-surface hardpan layer (Bntj) and weak sub-soil salinity; with significant amounts of moderately well drained, sodic soil with a more strongly expressed hardpan layer (Bnt) and stronger sub-soil salinity; and inclusions of well drained, non-saline, non-sodic, black soil with no hardpan layer.	Nearly level to very gently sloping upper to crest slope positions	0.5 - 2%
9	DYD1/3	BL.SO BL.SS SZ.LG	DYD KLM FMN	50-80% 15-30% 0-15%	Dominantly well to moderately well drained, sodic soil with a weakly expressed sub-surface hardpan layer (Bntj) and weak sub-soil salinity; with significant amounts of moderately well drained, sodic soil with a more strongly expressed hardpan horizon and stronger sub-soil salinity; and inclusions of poorly drained, saline and sodic, strongly gleyed soil with a dense, clayey sub-surface hardpan layer.	Very gently sloping, mid to lower slope positions leading to local depressions	2 - 5%
10	DYD1/4	BL.SO BL.SS O.BL	DYD KLM EOR	50-80% 15-30% 0-15%	Dominantly well drained, sodic soil with a weakly expressed sub-surface hardpan layer (Bntj) and weak sub-soil salinity; with significant amounts of moderately well drained, sodic soil with a more strongly expressed hardpan layer (Bnt) and moderate subsoil salinity; and inclusions of well drained, non-saline, non-sodic, black soils with no hardpan horizon.	Gently sloping, mid to upper slope positions	5 - 9%

continued . . .

Table 3.9 Concluded.

Map Unit No.	Map Unit Symbol	Soil Classification Composition: Soil Subgroup	Soil Series	Estimated Proportion	Non-Technical Description of the Soil Composition of the Map Unit	Description of the Landscape Position Occupied by the Unit	Slope Percent
11	EOR1/2	O.BL BL.SO BL.SS	EOR DYD KLM	50-80% 15-30% 0-15%	Dominantly well drained, non-saline, non-sodic soil with no sub-surface hardpan layer and no subsoil salinity; with significant amounts of sodic soil with a weakly expressed hardpan layer (Bntj) and weak subsoil salinity; and inclusions of sodic soil with a strongly expressed hardpan layer (Bnt) and moderate subsoil salinity .	Nearly level, upper slope to crest landscape positions	0.5 - 2%
12	EOR1/3	O.BL BL.SO BL.SS	EOR DYD KLM	50-80% 15-30% 0-15%	Dominantly well drained, non-saline, non-sodic soil with no sub-surface hardpan layer and no sub-soil salinity; with significant amounts of moderately well drained sodic soil with a weakly expressed hardpan layer (Bntj) and weak sub-soil salinity; and inclusions of moderately well drained sodic soil with a strongly expressed hardpan layer (Bnt).	Very gently sloping upper to mid slope positions leading to very gently sloping toe slopes	2 - 5%
13	EOR1/4	O.BL BL.SO R.BL	EOR DYD N/A	50-80% 0-15% 0-15%	Dominantly well drained, non-saline, non-sodic soil with no sub-surface hardpan layer and no sub-soil salinity; with minor inclusions of well drained, sodic soil with a weakly expressed hardpan layer (Bntj) and weak sub-soil salinity; and of well drained, non-saline, non-sodic soil with a thin, eroded topsoil layer lying directly on calcareous parent material.	Gently sloping, upper to crest landscape positions	5 - 9%
14	EOR1/5	O.BL BL.SO R.BL	EOR DYD N/A	50-80% 0-15% 0-15%	Dominantly well drained, non-saline, non-sodic soil with no sub-surface hardpan layer and no sub-soil salinity; with minor inclusions of moderately well drained sodic soil with a weakly expressed hardpan layer (Bntj) and weak sub-soil salinity; and of well drained, non-saline soil with an eroded topsoil layer lying directly on calcareous parent material.	Moderately sloping crest to lower slope positions	9 - 15%

Table 3.10 Final values for hydrological properties for each of the main Soil Series and horizons.

Horizon Type	Horizon Depth (cm)	Ksat mm/hr	KP0 vol (%)	KP33 vol (%)	KP1500 vol (%)	Bulk Density g/cc	Total Porosity (%)
Soil Series: EOR							
Ap	0-12	8.0	51	28	14	1.30	51
Bm1	12-34	20.0	45	28	12	1.45	45
Btnj	34-40	10.0	43	29	13	1.50	43
BCsa	40-60	3.0	43	20	10	1.50	43
Ccasa	60-100	3.0	43	19	12	1.50	43
Soil Series: DYD							
Ah	0-14	7.0	55	22	8	1.20	55
Ae	14-18	1.0	48	16	8	1.30	51
AB/Bm	18-25	1.0	47	23	14	1.40	47
Bntj	25-50	0.3	43	23	14	1.50	43
BCsa	50-62	3.0	42	23	14	1.55	42
Ccasa	62-100	3.0	42	20	8	1.55	42
Soil Series: KLM							
Ap	0-13	3.0	59	20	16	1.10	59
Ahegj	13-22	1.0	59	16	8	1.10	59
Bnt	22-45	0.3	45	30	20	1.45	45
BCsa	45-65	3.0	43	25	16	1.55	43
Csk1	65-80	3.0	43	21	12	1.50	43
Csk2	80-110	3.0	43	21	12	1.50	43
Soil Series: FMN							
Ah	0-10	3.0	59	34	12	1.10	59
Ahegsk	10-12	1.0	59	34	12	1.10	59
Bngtj	12-27	0.5	43	29	20	1.50	43
BCsakg	27-40	0.5	40	22	14	1.60	40
Ccasag	40-100	3.0	40	22	14	1.60	40
Soil Series: COR							
Ahg	0-18	6.0	58	34	12	1.10	58
Aheg	18-25	0.3	55	22	12	1.20	55
Aeg	25-28	0.3	51	18	8	1.30	51
Btg	28-50	0.3	43	24	12	1.50	43
BCg	50-95	1.0	42	33	17	1.55	42
Ccag	95-100	1.0	42	16	10	1.55	42

Note: The values for saturated hydraulic conductivity, volumetric moisture at saturation (KP0), 1/3 bar (KP33) and 15 bar (KP1500), bulk density and total porosity were assigned to each Soil Series on the basis of both field tests and consultation of the Alberta Soil Layer File (SLF).

Table 3.11 Snow depth and corresponding terrain derivitives at the 44 snow pack sample sites

Site Number	Grid Row	Grid Col	Survey Elev (m)	Grid Elev (m)	Snow Depth (cm)	Upslope Area Count	Profile Curve	Plan Curve	Log Transform of Upslope	Log Transform of Plan
153	57	89	722.20	722.3	5.0	3	0.163	-3.236	1.39	-1.44
154	157	4	726.48	726.7	10.0	7	0.017	-2.869	2.08	-1.35
155	95	58	722.79	722.9	10.0	6	-0.134	-4.051	1.95	-1.62
156	95	116	728.02	727.8	10.0	6	-0.090	0.286	1.95	0.25
157	110	107	724.18	724.1	30.0	20	-1.597	-5.246	3.04	-1.83
172	78	79	723.53	723.6	12.0	13	0.552	-3.908	2.64	-1.59
173	88	117	726.89	726.9	3.0	1	-0.172	-60.771	0.69	-4.12
174	84	118	727.17	727.1	5.0	1	-0.172	18.231	0.69	2.95
175	68	118	728.00	727.4	3.0	1	0.127	2.948	0.69	1.37
176	68	112	727.05	727.0	3.0	1	0.152	3.416	0.69	1.48
177	68	108	725.02	724.9	3.0	3	0.000	0.000	1.39	0.00
178	68	105	724.22	724.2	3.0	6	-0.228	0.000	1.95	0.00
179	68	103	723.91	723.8	13.0	31	0.305	-3.820	3.47	-1.57
180	67	101	723.49	723.5	10.0	33	-0.162	3.013	3.53	1.39
181	68	99	723.35	723.3	13.0	80	-0.076	-7.247	4.39	-2.11
182	15	138	721.29	0.0	4.0	1	0.197	1.761	0.69	1.01
183	18	139	722.93	722.9	30.0	294	-0.359	-6.735	5.69	-2.04
184	35	99	721.99	721.9	18.0	109	-0.412	-12.299	4.70	-2.58
185	59	83	721.79	721.9	15.0	376	0.305	-11.459	5.93	-2.52
186	52	120	726.34	726.2	5.0	1	-0.120	-1.902	0.69	-1.06
187	40	115	726.17	726.1	5.0	1	-0.050	5.650	0.69	1.89
188	29	115	725.10	725.0	3.0	1	0.288	3.499	0.69	1.50
189	148	22	725.06	725.1	13.0	167	0.000	0.000	5.12	0.00
190	120	43	727.49	727.4	8.0	2	-0.229	0.000	1.10	0.00
191	64	64	721.88	722.0	30.0	90	-0.523	-0.978	4.51	-0.68
192	66	55	723.03	723.1	13.0	38	-0.229	0.000	3.66	0.00
193	68	33	725.27	725.3	10.0	10	-0.336	2.899	2.40	1.36
194	86	18	722.68	722.8	56.0	283	-0.286	-18.231	5.65	-2.95
197	139	93	724.86	724.9	41.0	281	-0.229	0.000	5.64	0.00
198	133	93	725.27	725.2	61.0	145	-0.419	-4.502	4.98	-1.70
199	131	90	725.78	725.8	8.0	9	0.076	3.241	2.30	1.44
200	68	92	723.10	723.3	5.0	1	-0.037	20.139	0.69	3.05
201	68	91	723.12	723.2	5.0	2	-0.003	-2.838	1.10	-1.34
202	69	87	722.68	722.8	33.0	447	-0.688	-15.174	6.11	-2.78
203	62	87	722.09	722.1	10.0	7	0.242	-0.535	2.08	-0.42
204	143	28	725.47	725.4	8.0	42	-0.324	0.506	3.76	0.41
205	137	34	726.74	726.7	5.0	3	0.000	0.000	1.39	0.00
207	65	127	0.00	726.8	4.0	2	-0.140	-4.190	1.10	-1.64
208	37	118	0.00	725.3	5.0	3	0.092	2.560	1.39	1.27
209	100	39	0.00	726.6	4.0	1	0.070	0.367	0.69	0.31
210	73	35	0.00	725.3	6.0	7	0.100	-0.652	2.08	-0.50
211	70	51	0.00	723.9	12.0	45	-0.076	-2.531	3.83	-1.26
212	137	10	0.00	725.9	7.0	4	0.045	-6.751	1.61	-2.04
300	24	124	0.00	723.4	10.0	26	-0.182	-7.435	3.30	-2.13

Table 3.12 Summary statistics for the topographical and snow depth variables

Statistic	Snow Depth	Upslope Area Count	Profile Curve	Plan Curve	Log of Upslope	Log of Plan Curve
N of cases	44	44	44	44	44	44
Maximum	3.0	1	-1.597	-60.771	0.690	-4.123
Minimum	61.0	447	0.552	20.139	6.110	3.051
Range	58.0	446	2.149	80.910	5.420	7.174
Mean	12.88	59	-0.103	-2.701	2.593	-0.492
Variance	181.68	12004	0.111	125.737	3.101	2.700
Standard Deviation	13.48	109.5	0.333	11.213	1.761	1.643
Skewness	2.153	2.187	-1.967	-3.004	0.593	0.168
Kurtosis	4.190	3.781	7.545	14.983	-0.965	-0.570
C.V.	1.046	1.847	-3.228	-4.152	0.679	3.341

Table 3.13 Pearson correlation matrix relating snow depth to the topographical indices upslope area, profile curvature and plan curvature.

	Snowdepth	Upslope	Plan	Prof	UpsT	PlanT
Snowdepth	1.000	0.684				
Upslope	0.684	1.000				
Plan	-0.207	-0.207	1.000			
Prof	-0.495	-0.246	0.153	1.000		
UpsT	0.754	0.835	-0.232	-0.345	1.000	
PlanT	-0.407	-0.422	0.793	0.227	-0.480	1.000

Table 3.14 Summary of output from a stepwise regression investigation of the relationship between snow depth and a selection of topographical indices.

CONST	UpsT	Prof	Disp	PlanT	r	r^2	F
-2.082	5.772				0.754	0.569	55.348
-1.371	5.067	-1.800			0.795	0.631	35.111
1.520	4.745	-10.306	-0.146		0.799	0.638	23.610
1.498	4.705	-10.281	-0.141	-0.120	0.800	0.639	17.277

Table 3.15 Summarized pond statistics for 18 ponds recorded on 13 field survey dates

Pond Field Survey No.	DEM Shed No.	DEM Pit Elev (m)	Mar-31	Apr-04	Apr-12	Apr-19	Apr-26	Map-03	May-10	May-17	May-24	Jul-04	Jul-11	Jul-25	Aug-10
7	4	723.7		724.130 0.430 450.000 83.500	724.065 0.365 325.000 58.625	723.970 0.270 225.000 30.750	723.915 0.215 225.000 18.375						723.905 0.205 225.000 16.125		
182	13	721.2			721.539 0.339 1625.000 225.875	721.459 0.259 1000.000 121.500	721.409 0.209 1000.000 71.500	721.349 0.149 550.000 34.450	721.304 0.104 550.000 9.700			721.339 0.139 550.000 28.950	721.429 0.229 1000.000 91.500	721.304 0.104 550.000 9.700	
8	14	724.7		724.965 0.265 575.000 69.875	724.870 0.170 275.000 24.250										
184	19	721.9		722.409 0.509 1600.000 581.900	722.344 0.444 2600.000 394.900	722.274 0.374 1475.000 246.650	722.229 0.329 1475.000 180.275	722.184 0.284 850.000 123.900	722.134 0.234 850.000 81.400	722.074 0.174 400.000 42.100	722.069 0.169 400.000 40.100	722.169 0.269 850.000 111.150	722.239 0.339 1475.000 195.025	722.114 0.214 850.000 64.400	721.994 0.094 125.000 11.750
6	23	722.7	723.005 0.305 2900 429.5	722.964 0.264 2275.000 333.100	722.940 0.240 2275.000 278.500	722.880 0.180 1300.000 161.500	722.845 0.145 1300.000 116.000	722.810 0.110 1300.000 70.500				722.975 0.275 2275.000 358.125	722.995 0.295 2275.000 403.625	722.880 0.180 1300.000 161.500	722.795 0.095 575.000 54.625
3	34	726.8					727.015 0.215 750.000 28.750								
185-E	35	721.7		722.120 0.420 5125.000 1032.500	722.052 0.352 4300.000 723.600	722.045 0.345 4300.000 693.500	722.005 0.305 4300.000 521.500	721.930 0.230 3075.000 284.750	721.875 0.175 1475.000 155.625	721.870 0.170 1475.000 148.250	721.865 0.165 1475.000 140.875	721.875 0.175 1475.000 155.625	721.930 0.230 3075.000 284.750	721.900 0.200 3075.000 192.500	721.870 0.170 1475.000 148.250
185-W	36	721.5		722.120 0.620 7025.000 1560.500	722.050 0.550 5625.000 1138.750	722.045 0.545 5625.000 1110.625	722.005 0.505 5625.000 885.625	721.930 0.430 4250.000 560.000	721.875 0.375 2675.000 365.625	721.870 0.370 2675.000 352.250	721.865 0.365 2675.000 338.875	721.875 0.375 2675.000 365.625	721.930 0.430 4250.000 560.000	721.900 0.400 4250.000 432.500	721.870 0.370 2675.000 352.250
2	50	726.9		727.050 0.150 1400.000 102.500			727.050 0.150 1400.000 102.500								
194	54	722.7		722.990 0.290 5400.000 751.000	722.990 0.290 5400.000 751.000	722.920 0.220 5400.000 373.000	722.850 0.150 2025.000 163.750	722.815 0.115 2025.000 92.875	722.800 0.100 2025.000 62.500	722.720 0.020 625.000 12.500	722.720 0.020 625.000 12.500	722.800 0.100 2025.000 62.500	722.860 0.160 2025.000 184.000	722.755 0.055 625.000 34.375	
173	57	726.9	727.11 0.21 2425 226.75	727.200 0.300 3150.000 445.000	727.020 0.120 1550.000 78.500	726.910 0.010 475.000 4.750									
5	58	726.8	727.045 0.245 1000 97.5	726.980 0.180 425.000 44.000	726.915 0.115 425.000 16.375										
155	64	722.9	723.27 0.37 4075 847.75	723.222 0.322 4075.000 652.150	723.175 0.275 3000.000 487.500	723.125 0.225 3000.000 337.500	723.065 0.165 1775.000 200.375					723.135 0.235 3000.000 367.500	723.210 0.310 4075.000 603.250	723.105 0.205 3000.000 277.500	722.990 0.090 850.000 76.500
157	70	723.8		724.205 0.405 2450.000 369.750	724.150 0.350 1800.000 267.500	724.095 0.295 1050.000 172.250	724.080 0.280 1050.000 156.500	723.940 0.140 600.000 36.500	723.930 0.130 600.000 30.500	723.890 0.090 125.000 11.250	723.890 0.090 125.000 11.250	723.850 0.050 125.000 6.250	723.885 0.085 125.000 10.625		
197	83	724.9		725.331 0.431 3700.000 999.700	725.256 0.356 3350.000 737.600	725.191 0.291 3000.000 523.000	725.161 0.261 3000.000 433.000	725.130 0.230 3000.000 340.000	725.075 0.175 1950.000 201.250	725.060 0.160 1950.000 172.000	725.055 0.155 1950.000 162.250	724.940 0.040 550.000 22.000	724.940 0.040 550.000 22.000		
9-W	88	724.8		725.160 0.360 1225.000 208.500	725.025 0.225 800.000 75.000										
9-E	90	724.2		724.575 0.375 3325.000 639.375	724.540 0.340 3325.000 523.000	724.495 0.296 2450.000 377.750	724.470 0.270 2450.000 316.500	724.405 0.205 2450.000 157.250	724.310 0.110 1225.000 34.750				724.405 0.205 2450.000 157.250		
189	94	725		725.450 0.450 5800.000 1007.500	725.350 0.350 4000.000 517.500	725.280 0.280 1900.000 279.500	725.240 0.240 1900.000 203.500	725.190 0.190 1025.000 117.250	725.100 0.100 1025.000 25.000			725.230 0.230 1900.000 184.500	725.305 0.305 4000.000 337.500	725.210 0.201 1900.000 146.500	725.115 0.115 1025.000 40.375

Note: Four numbers are listed for each date on which a pond was observed and recorded. The top number is the maximum elevation of the pond in m; the second number is the maximum pond depth in m; the third is the area of the pond in m^2 and the fourth is the volume of the pond in m^3. Pond area and pond volume were computed using the Lunty DEM in combination with the program PONDMAP.

Table 3.16 A comparison of change in pond volume between survey dates and total recorded pan evaporation over the equivalent periods for each of the surveyed ponds and dates.

Pond Field Survey No.	DEM Shed No.	DEM Pit Elev (m)	Mar-31	Apr-04	Apr-12	Apr-19	Apr-26	May-03	May-10	May-17	May-24	Jul-04	Jul-11	Jul-25	Aug-10
7	4	723.7		-3.600	-6.890	-6.255	-5.355						-16.425		
				83.500	-24.875	-27.875	-12.375						16.125		
				87.100	-17.985	-21.620	-7.020						32.550		
182	13	721.2			-34.450	-27.800	-23.800	-16.610	-27.390			-190.740	-73.000	-44.935	
					225.875	-104.375	-50.000	-37.050	-24.750			28.950	62.550	-81.800	
					260.325	-76.575	-26.200	-20.440	0.000			219.690	135.550	-36.865	
8	14	724.7		-4.600	-5.830										
				69.875	-45.625										
				74.475	-39.795										
184	19	721.9		-12.800	-55.120	-41.005	-35.105	-25.670	-42.330	-18.440	-14.080	-294.780	-107.675	-69.445	-124.375
				581.900	-187.000	-148.250	-66.375	-56.375	-42.500	-39.300	-2.000	71.050	83.875	-130.625	-52.650
				594.700	-131.880	-107.245	-31.270	-30.705	-0.170	-20.860	0.000	365.830	191.550	-61.180	71.725
6	23	722.7	.000	-18.200	-48.230	-36.140	-30.940	-39.260				-788.970	-166.075	-106.210	-572.125
			.429	-96.400	-54.600	-117.000	-45.500	-45.500				358.125	45.500	-242.125	-106.875
			.429	-78.200	-6.370	-80.860	-14.560	-6.240				1147.095	211.575	-135.915	0.000
3	34	726.8					-17.850								
							28.750								
							46.600								
185-E	35	721.7		-41.000	-91.260	-119.540	-102.340	-92.865	-73.455	-67.998	-51.920	-511.530	-224.475	-251.228	-
															1467.625
				1032.500	-308.900	-30.100	-172.000	-236.750	-129.125	-7.375	-7.375	14.750	129.125	-92.250	-44.250
				1073.500	-217.640	0.000	-69.660	-143.885	-55.670	0.000	0.000	526.280	353.600	0.000	0.000
185-W	36	721.5		-56.200	-119.250	-156.375	-133.875	-128.350	-133.215	-	-94.160	-927.690	-310.250	-347.225	-
										123.318					2261.625
				1056.500	-421.750	-28.125	-225.000	-325.625	-194.375	-13.375	-13.375	26.750	194.375	-127.500	-80.250
				1112.700	-302.500	0.000	-91.125	-197.275	-61.160	0.000	0.000	954.440	504.625	0.000	0.000
2	50	726.9		-11.200			-33.320								
				102.500			0.000								
				113.700											
194	54	722.7		-43.200	-114.480	-150.120	-48.195	-61.155	-100.845	-28.813	-22.000	-702.270	-147.825	-51.063	
				751.000	0.000	-378.000	-209.250	-70.875	-30.375	-50.000	0.000	50.000	121.500	-149.625	
				794.200	114.480	-227.880	-161.055	-9.720		-21.187	22.000	752.270	269.325	-98.562	
173	57	726.9	.000	-25.2	-32.86	-13.205									
			.226	218.250	-366.500	-73.750									
			.226	243.450	-333.640	-60.545									
5	58	726.8	.000	-3.400	-9.010										
			.975	-53.500	-27.625										
			.975	-50.100	-18.615										
155	64	722.9	.000	-32.600	-63.600	-83.400	-42.245					-1040.4	-297.475	-245.1	-845.75
			.847	-195.600	-164.650	-150.000	-137.125					367.500	235.750	-325.750	-201.000
			.847	-163.000	-101.050	-66.600	-94.880					1407.900	533.225	-80.650	0.000
157	70	723.8		-19.600	-38.160	-29.190	-24.990	-18.120	-29.880	-5.763	-4.400	-43.350	-9.125		
				369.750	-102.250	-95.250	-15.750	-120.000	-6.000	-19.250	0.000	-5.000	4.375		
				389.350	-64.090	-66.060	0.000	-101.880	0.000	-13.487	4.400	0.000	13.500		
197	83	724.9		-29.600	-71.020	-83.400	-71.400	-90.600	-97.110	-89.895	-68.640	-190.740	-40.150		
				999.700	-262.100	-214.600	-90.000	-93.000	-138.750	-29.250	-9.750	-140.250	0.000		
				1029.300	-191.080	-131.200	-18.600	-2.400	-41.640	0.000	0.000	0.000	40.150		
9-W	88	724.8		-9.800	-16.900										
				208.500	-133.500										
				218.300	-116.600										
9-E	90	724.2		-26.600	-70.490	-68.110	-58.310	-73.990	-61.005				-178.850		
				639.375	-116.375	-145.250	-61.250	-159.250	-122.500				157.250		
				665.975	-45.885	-77.140	-2.940	-85.260	-61.495				336.100		
189	94	725		-46.400	-84.800	-52.820	-45.220	-30.955	-51.045			-658.920	-292.000	-155.230	-
															1019.875
				1007.5	-490.000	-238.000	-76.000	-86.250	-92.250			184.500	153.000	-191.000	-106.125
				1053.900	-405.200	-185.180	-30.780	-55.295	-41.205			843.420	445.000	-35.770	0

Note: Three numbers are listed for each date on which a pond was observed and recorded. The top number is the estimated potential loss of water from a pond by evaporation (m^3) calculated as the product of the observed pan evaporation for that interval times the computed surface area of the pond. Potential evaporation is given a negative sign to denote a loss from the system. The second line of numbers is the computed change in pond volume from the previous survey date (m^3). A negative value indicates there has been a reduction in pond volume (loss of water). A positive number indicates a gain in pond volume. The third line of numbers for each pond represents the difference between the change in volume of the pond from the previous date and the maximum potential loss from evaporation (m^3). It may be thought of as the net of runoff inputs minus infiltration losses. If negative, it indicates that some of the reduction in volume of the pond must be ascribed to losses by infiltration. If positive, the indication is that some of the increase in pond volume must result from an excess of runoff over infiltration (and evaporation).

Table 4.1 Extensions and modifications to the original Watersh utilities

Function modified	Original operation	Modified operation
Dealing with missing values	Not available	Drain direction not computed for cells with defined missing values
Assigning a flow direction to a cell at the edge of the matrix	All cells at edge of matrix automatically assigned a flow direction off the edge into the "outside world". Edge of matrix treated as infinite sink.	Option added to not allow flow to the "outside world". Flow from an edge cell is directed to its lowest downslope neighbour within matrix. If no neighbour is lower the cell is a pit centre or outflow point and is assigned a value of 5 for flow direction. These cells are used as seed points for growing basins and defining catchments
Assigning flow directions to flat cells	Checked expanding concentric search area for first cell with positive downslope gradient and directed flow from all flat cells to this first cell with a defined downslope flow direction	Flow directions for flat areas were computed first as if they were growing back from cells with assigned directions, then, if a cell still was not assigned a flow direction, flow directions were assigned as if water were flowing away from an upslope cell with a defined flow direction into a cell in a flat area that had no lower connected cells
Providing options for interactive pit removing	Option existed only to either remove all pits or remove a single identified pit	Options extended to remove all or selected pits according to their volume, area, depth or notional total runoff (mm) required to fill
Generating details of pit location, size, volume and connectivity	Not available initially	Inserted ability to compute and write out ASCII table of data to characterise pits. Table could be written for a single pit, all pits, or a list of pits. Pits could be numbered sequentially or numbered according to data provided by an external "pit list" file identifying row, col and number for each pit or interest

Table 4.2 Example of pond statistics produced by Watersh program

Shed No.	Shed Area	Pit Row	Pit Col	Pit Elev	Pit Vol	Pit Area	Next Pit	In Row	In Col	In Elev	Out Row	Out Col	Out Elev	Pour Elev
23	1360	51	42	722.7	7.5	52	1	12	32	724.9	11	31	724.9	724.9
23	1360	51	42	722.7	7.5	52	8	12	32	724.9	11	32	724.9	724.9
23	1360	51	42	722.7	7.5	52	14	14	49	725.9	14	50	725.9	725.9
23	1360	51	42	722.7	7.5	52	15	19	25	725.5	18	24	725.4	725.5
23	1360	51	42	722.7	7.5	52	33	53	49	722.9	54	50	722.9	722.9
23	1360	51	42	722.7	7.5	52	16	26	26	725.5	25	25	725.4	725.5
23	1360	51	42	722.7	7.5	52	30	46	25	724.7	47	25	724.7	724.7
23	1360	51	42	722.7	7.5	52	28	58	31	725.0	59	30	725.0	725.0
23	1360	51	42	722.7	7.5	52	39	65	45	724.9	66	46	724.8	724.9
23	1360	51	42	722.7	7.5	52	54	69	37	725.5	70	36	725.4	725.5

Table 4.3 Structure of the dBase III+ file of watershed and pond statistics

Field Num.	Field Name	Field Type	Field Width	Num Dec Places	Field Description
1	SHEDNO	NUMERIC	3	0	Unique sequential number to identify each catchment
2	SHEDAREA	NUMERIC	5	0	Total area of the catchment (in grid cell units)
3	PITROW	NUMERIC	3	0	Row location of pit centre (or seed point) in matrix
4	PITCOL	NUMERIC	3	0	Column location of pit centre (or seed point) in matrix
5	PITELEV	NUMERIC	5	1	Elevation of pit centre (m) (lowest point in catchment)
6	PITVOL	NUMERIC	8	3	Volume (in m) of the pit (excludes volume of underlying pits "removed" prior to calculating this volume)
7	PITAREA	NUMERIC	4	0	Maximum area of pit (in grid units) when full
8	DRAINSTO	NUMERIC	3	0	ID number of neighbour catchment that pit drains to
9	INROW	NUMERIC	3	0	Row inside this catchment where overspill will occur
10	INCOL	NUMERIC	3	0	Column inside this catchment where overspill will occur
11	INELEV	NUMERIC	5	1	Elevation (m) of pour cell inside catchment boundary
12	OUTROW	NUMERIC	3	0	Row outside this catchment where overspill will go
13	OUTCOL	NUMERIC	3	0	Column outside this catchment where overspill will go
14	OUTELEV	NUMERIC	5	1	Elevation (m) of pour cell outside catchment boundary
15	POURELEV	NUMERIC	5	1	Pour elevation (m) (lower of values in fields 11 or 14)
16	NEXTPIT	NUMERIC	3	0	Second choice catchment for possible overspill point
17	ROW2	NUMERIC	3	0	Row location of second choice pour point (if needed)
18	COL2	NUMERIC	3	0	Column location of second choice pour point (if needed)
19	VOLTOFLOOD	NUMERIC	8	3	Volume of water (m) required to fill that portion of depression not considered part of underlying pits
20	PREVOL	NUMERIC	8	3	Volume of water already in any nested depressions (m) (only relevant for "higher order" depressions)
21	TOTALVOL	NUMERIC	8	3	Total volume of depression (m) when full (calculated as VolToFlood + PreVol for any "nested" depressions)
22	VARATIO	NUMERIC	5	1	Ratio of volume of pit to area of catchment (* 1000) (approximates the mm of rainfall required to fill pit)
23	MMTOFLOOD	NUMERIC	7	2	Estimate of mm of rainfall required to fill pit (not strictly equal to Vol/Area for "higher order" pits)
24	FINAL	LOGICAL	1		Logical field to identify catchments that drain to "outside world" at the edge of the data matrix

Table 4.4 Watershed and pond statistics for the Lunty site

Shed No.	Shed Area	Pit Row	Pit Col	Pit Elev	Pit Vol	Pit Area	Drains To	Pit Row	In Col	In Elev	Out Row	Out Col	Out Elev	Pour Elev	Next Pit	Row 2	Col 2	Volto Flood	Prev Vol	Total Vol	V/A Ratio	mm to Flood	Edge Pit?
1	496	1	10	722.6	0.0	179	2	1	28	724.0	2	29	724.0	722.6	1	2	29	116.2	0.0	116.2	0.0	234.27	.T.
2	40	1	30	723.9	0.0	1	1	1	29	724.0	1	28	724.0	723.9	2	1	28	0.1	0.0	0.1	0.0	2.50	.T.
3	127	1	43	724.0	0.0	8	2	1	35	724.1	2	34	724.1	724.0	3	2	34	0.8	0.0	0.8	0.0	6.30	.T.
4	124	1	61	723.7	0.0	9	5	1	64	724.0	1	65	724.0	723.7	4	1	65	1.5	0.0	1.5	0.0	12.10	.T.
5	493	1	80	721.7	0.0	34	6	1	87	722.2	1	88	722.2	721.7	5	1	88	7.9	0.0	7.9	0.0	16.02	.T.
6	215	1	92	721.9	0.0	7	5	1	88	722.2	1	87	722.2	721.9	6	1	87	1.4	0.0	1.4	0.0	6.51	.T.
7	57	1	108	723.7	0.0	1	10	1	110	723.8	1	111	723.8	723.8	10	1	111	0.1	0.0	0.1	0.0	1.75	.T.
8	79	7	37	724.2	0.2	2	2	6	36	724.3	5	35	724.3	724.3	2	5	35	0.2	0.0	0.2	2.5	2.53	.F.
9	40	7	135	721.4	0.3	3	11	8	135	721.5	8	136	721.5	721.5	11	8	136	0.3	0.0	0.3	7.5	7.50	.F.
10	211	8	131	721.7	0.3	3	13	9	131	721.8	10	131	721.8	721.8	13	10	131	0.3	0.0	0.3	1.4	1.42	.F.
11	36	8	140	721.2	0.0	1	12	9	139	721.3	10	139	721.3	721.3	12	10	139	0.1	0.0	0.1	0.0	2.78	.F.
12	24	11	139	721.2	0.1	1	11	10	139	721.3	9	139	721.3	721.3	13	13	140	0.1	0.0	0.1	4.2	4.17	.F.
13	847	13	140	721.2	0.0	1	12	12	140	721.3	12	139	721.3	721.3	144	12	139	0.1	0.0	0.1	0.0	0.12	.F.
14	146	14	59	724.7	1.3	11	4	10	59	724.9	9	58	724.9	724.9	4	9	58	1.3	0.0	1.3	8.9	8.90	.F.
15	15	18	24	725.4	0.1	1	23	18	25	725.5	18	26	725.4	725.5	23	18	26	0.1	0.0	0.1	6.7	6.67	.F.
16	12	25	25	725.4	0.1	1	23	25	26	725.5	25	27	725.4	725.5	23	25	27	0.1	0.0	0.1	8.3	8.33	.F.
17	274	26	1	723.9	0.0	76	30	32	9	724.7	33	9	724.7	723.9	17	33	9	30.0	0.0	30.0	0.0	109.49	.T.
18	11	34	119	725.2	0.2	2	19	34	119	725.3	34	118	725.2	725.3	19	34	118	0.2	0.0	0.2	18.2	18.18	.F.
19	1011	37	98	721.9	20.9	96	21	44	93	722.4	45	93	722.4	722.4	21	45	93	20.9	0.0	20.9	20.7	20.67	.F.
20	126	40	127	725.5	0.2	2	13	40	127	725.5	39	128	725.6	725.6	13	39	128	0.2	0.0	0.2	1.6	1.59	.F.
21	224	46	92	722.2	0.9	8	19	45	93	722.4	45	94	722.3	722.4	25	49	89	0.9	0.0	0.9	4.0	4.02	.F.
22	18	50	1	724.9	0.0	1	45	51	1	725.0	52	1	725.0	724.9	45	52	1	0.1	0.0	0.1	0.0	5.56	.T.
23	1360	51	42	722.7	7.5	52	33	53	49	722.9	54	50	722.9	722.9	128	54	50	7.5	0.0	7.5	5.5	5.51	.F.
24	348	51	123	726.1	0.1	1	20	50	124	726.2	49	125	726.1	726.2	20	49	125	0.1	0.0	0.1	0.3	0.29	.F.
25	199	55	82	721.7	0.1	1	27	56	81	721.8	57	81	721.8	721.8	116	57	81	0.1	0.0	0.1	0.5	0.50	.F.
26	36	56	73	721.6	0.4	4	29	58	73	721.7	59	72	721.7	721.7	29	59	72	0.4	0.0	0.4	11.1	11.11	.F.
27	487	59	82	721.7	0.2	2	35	58	82	721.7	59	81	721.8	721.8	116	59	81	0.2	0.0	0.2	0.4	0.41	.F.
28	55	61	16	722.8	0.1	1	30	59	17	722.9	59	16	722.9	722.9	126	59	16	0.1	0.0	0.1	1.8	1.82	.F.
29	93	61	70	721.6	0.1	1	26	59	72	721.7	58	73	721.7	721.7	33	59	69	0.1	0.0	0.1	1.1	1.08	.F.
30	792	62	14	722.8	0.3	3	32	61	13	722.9	62	12	722.8	722.9	28	59	17	0.3	0.0	0.3	0.4	0.38	.F.
31	27	62	135	726.9	0.3	3	34	62	135	727.0	63	135	726.9	727.0	34	63	135	0.3	0.0	0.3	11.1	11.11	.F.
32	46	63	12	722.8	0.2	2	45	65	12	722.9	66	12	722.9	722.9	30	60	13	0.2	0.0	0.2	4.3	4.35	.F.
33	1080	63	67	721.6	0.8	8	29	59	69	721.7	60	70	721.7	721.7	36	64	71	0.8	0.0	0.8	0.7	0.74	.F.
34	74	64	135	726.8	0.4	3	24	61	132	727.0	61	131	727.0	727.0	24	61	131	0.4	0.0	0.4	5.4	5.41	.F.
35	521	65	78	721.7	1.5	15	25	57	81	721.8	56	81	721.8	721.8	116	56	181	1.5	0.0	1.5	2.9	2.88	.F.
36	63	66	72	721.5	0.2	1	29	64	72	721.7	63	71	721.7	721.7	117	63	71	0.2	0.0	0.2	3.2	3.17	.F.
37	549	66	81	721.8	0.1	1	35	65	80	721.9	64	79	721.8	721.9	118	64	79	0.1	0.0	0.1	0.2	0.18	.F.
38	26	69	13	722.9	0.1	1	45	68	13	723.0	69	12	723.0	723.0	127	69	12	0.1	0.0	0.1	3.8	3.85	.F.
39	424	69	65	721.9	0.2	2	33	67	65	722.0	66	65	722.0	722.0	119	66	65	0.2	0.0	0.2	0.5	0.47	.F.
40	56	71	124	726.8	0.1	1	24	70	124	726.9	69	123	726.9	726.9	24	69	123	0.1	0.0	0.1	1.8	1.79	.F.
41	204	73	74	722.3	0.1	1	36	73	73	722.4	72	73	722.4	722.4	121	72	73	0.1	0.0	0.1	0.5	0.49	.F.
42	192	74	97	723.5	0.1	1	37	74	96	723.6	73	95	723.5	723.6	132	73	95	0.1	0.0	0.1	0.5	0.52	.F.
43	8	74	138	727.3	0.1	1	50	73	138	727.4	74	137	727.4	727.4	50	74	137	0.1	0.0	0.1	12.5	12.50	.F.
44	5	74	140	727.4	0.0	1	44	74	140	727.4	74	140	727.4	727.4	44	74	140	0.1	0.0	0.1	0.0	20.00	.T.
45	216	75	8	722.7	1.3	13	48	76	8	722.8	77	9	722.8	722.8	123	77	9	1.3	0.0	1.3	6.0	6.02	.F.
46	40	79	120	726.9	0.1	1	51	80	120	727.0	81	121	726.9	727.0	143	81	121	0.1	0.0	0.1	2.5	2.50	.F.
47	20	80	1	723.3	0.0	1	59	80	1	723.3	81	1	723.4	723.3	47	81	1	0.1	0.0	0.1	0.0	5.00	.T.
48	37	80	9	722.7	0.3	3	45	77	9	722.8	76	8	722.8	722.8	123	76	8	0.3	0.0	0.3	8.1	8.11	.F.
49	44	81	5	722.9	0.1	1	48	82	6	723.0	81	7	722.9	723.0	48	81	7	0.1	0.0	0.1	2.3	2.27	.F.
50	138	81	127	726.9	0.3	3	51	80	126	727.0	81	125	727.0	727.0	51	81	125	0.3	0.0	0.3	2.2	2.17	.F.
51	78	83	122	726.9	0.9	9	50	80	125	727.0	80	126	727.0	727.0	57	84	119	0.9	0.0	0.9	11.5	11.54	.F.
52	23	85	67	723.1	0.1	1	33	84	68	723.2	83	69	723.1	723.2	130	83	69	0.1	0.0	0.1	4.3	4.35	.F.
53	283	86	18	722.7	0.2	2	54	83	19	722.8	83	18	722.8	722.8	122	83	18	0.2	0.0	0.2	0.7	0.71	.F.
54	514	89	16	722.7	0.7	7	53	87	17	722.8	86	18	722.7	722.8	122	86	18	0.7	0.0	0.7	1.4	1.36	.F.
55	294	90	62	723.0	0.1	1	64	88	60	723.1	89	60	723.1	723.1	129	89	60	0.1	0.0	0.1	0.3	0.34	.F.
56	26	93	10	722.9	0.3	3	59	93	9	723.0	93	8	723.0	723.0	59	93	8	0.3	0.0	0.3	11.5	11.54	.F.
57	187	93	119	726.9	1.9	19	51	84	119	727.0	84	120	727.0	727.0	46	80	120	1.9	0.0	1.9	10.2	10.16	.F.
58	171	93	131	726.8	6.1	40	70	96	129	727.1	97	129	727.1	727.1	70	97	129	6.1	0.0	6.1	35.7	35.67	.F.
59	134	95	4	722.9	1.7	17	59	95	1	723.0	95	1	723.0	723.0	59	95	1	1.7	0.0	1.7	12.7	12.69	.T.
60	30	96	10	722.8	0.4	3	56	94	11	723.0	93	10	722.9	723.0	56	93	10	0.4	0.0	0.4	13.3	13.33	.F.
61	108	96	16	722.8	0.2	2	54	94	16	722.9	93	16	722.8	722.9	125	93	16	0.2	0.0	0.2	1.9	1.85	.F.
62	8	96	38	726.4	0.1	1	53	95	38	726.5	96	37	726.5	726.5	53	96	37	0.1	0.0	0.1	12.5	12.50	.F.
63	870	98	7	722.8	0.4	3	59	96	6	723.0	95	6	723.0	723.0	59	95	6	0.4	0.0	0.4	0.5	0.46	.F.
64	1389	98	61	722.9	10.4	70	55	92	63	723.1	91	63	723.1	723.1	129	91	63	10.4	0.0	10.4	7.5	7.49	.F.
65	30	99	138	726.9	0.3	3	68	98	137	727.0	99	136	727.0	727.0	65	99	136	0.3	0.0	0.3	10.0	10.00	.T.
66	21	105	115	724.0	0.2	1	69	105	114	724.2	106	113	724.2	724.2	137	106	113	0.2	0.0	0.2	9.5	9.52	.F.
67	420	106	107	723.8	0.7	4	69	109	108	724.1	108	109	724.0	724.1	134	108	109	0.7	0.0	0.7	1.7	1.67	.F.
68	54	106	140	726.8	0.0	13	74	107	140	726.9	108	139	726.8	726.9	68	108	139	1.3	0.0	1.3	0.0	24.07	.T.
69	173	109	113	723.8	0.2	2	70	109	114	723.9	110	115	723.8	723.9	133	110	115	0.2	0.0	0.2	1.2	1.16	.F.
70	490	111	115	723.8	0.2	2	69	110	114	723.9	109	113	723.8	723.9	133	109	113	0.2	0.0	0.2	0.4	0.41	.F.
71	52	114	75	725.5	0.1	1	64	114	74	725.6	113	73	725.6	725.6	64	113	73	0.1	0.0	0.1	1.9	1.92	.F.
72	25	125	45	727.4	0.1	1	64	123	44	727.5	122	43	727.5	727.5	64	122	43	0.1	0.0	0.1	4.0	4.00	.F.
73	13	126	74	725.7	0.1	1	88	126	74	725.7	127	74	725.8	725.8	88	127	74	0.1	0.0	0.1	7.7	7.69	.F.
74	460	128	140	724.2	0.0	89	70	120	126	725.3	119	126	725.3	725.3	74	119	126	34.8	0.0	34.8	0.0	75.65	.T.
75	14	130	44	727.4	0.1	1	89	129	44	727.5	130	43	727.5	727.5	89	130	43	0.1	0.0	0.1	7.1	7.14	.F.
76	22	130	47	727.5	0.1	1	75	130	46	727.6	129	45	727.5	727.6	75	129	45	0.1	0.0	0.1	4.5	4.55	.F.
77	16.	130	82	726.0	0.1	1	91	130	82	726.0	131	82	726.1	726.1	91	131	82	0.1	0.0	0.1	6.2	6.25	.F.
78	24	131	3	725.9	0.2	2	63	131	4	726.0	130	5	725.9	726.0	63	130	5	0.2	0.0	0.2	8.3	8.33	.F.
79	71	134	11	725.8	0.1	1	85	133	12	725.9	134	13	725.9	725.9	85	134	13	0.1	0.0	0.1	1.4	1.41	.F.
80	6	136	1	726.2	0.0	1	78	135	1	726.2	134	1	726.2	726.2	80	131	1	0.1	0.0	0.1	0.0	16.67	.T.
81	152	136	20	725.5	1.1	8	85	136	19	725.6	137	18	725.7	725.7	142	137	18	1.1	0.0	1.1	7.2	7.24	.F.
82	48	138	90	724.9	0.8	7	86	142	91	725.1	141	92	725.0	725.1	139	141	92	0.8	0.0	0.8	16.7	16.67	.F.
83	527	139	98	724.9	0.6	6	84	138	98	724.9	139	97	725.0	725.0	135	139	97	0.6	0.0	0.6	1.1	1.14	.F.
84	302	140	94	724.9	1.4	14	86	141	94	725.0	142	93	724.9	725.0	83	138	98	1.4	0.0	1.4	4.6	4.64	.F.
85	136	141	15	725.3	0.4	4	87	142	16	725.4	142	17	725.4	725.4	87	142	17	0.4	0.0	0.4	2.9	2.94	.F.
86	50	142	93	724.9	0.1	1	84	142	93	724.9	141	94	725.0	725.0	84	141	94	0.1	0.0	0.1	2.0	2.00	.F.
87	17	143	19	725.2	0.1	1	93	143	19	725.2	144	19	725.3	725.3	140	144	19	0.1	0.0	0.1	5.9	5.88	.F.
88	124	144	73	724.8	0.5	5	97	147	73	724.9	148	73	724.9	724.9	136	148	73	0.5	0.0	0.5	4.0	4.03	.F.
89	243	145	24	725.0	0.2	2	93	145	24	725.0	146	23	725.1	725.1	138	146	23	0.2	0.0	0.2	0.8	0.82	.F.
90	48	146	80	724.2	0.1	1	99	147	80	724.3	148	80	724.3	724.3	99	148	80	0.1	0.0	0.1	2.1	2.08	.F.
91	165	147	77	724.3	0.7	7	90	144	78	724.4	145	79	724.3	724.4	90	145	79	0.7	0.0	0.7	4.2	4.24	.F.
92	71	147	122	726.6	0.8	8	104	148	120	726.7	149	119	726.6	726.7	104	149	119	0.8	0.0	0.8	11.3	11.27	.F.
93	167	148	22	725.0	0.3	3	94	148	23	725.1	148	24	725.0	725.1	138	148	24	0.3	0.0	0.3	1.8	1.80	.F.
94	339	149	24	725.0	0.5	5	89	147	24	725.1	146	24	725.1	725.1	138	146	24	0.5	0.0	0.5	1.5	1.47	.F.
95	36	149	105	725.5	0.1	1	100	148	105	725.6	149	104	725.6	725.6	100	149	104	0.1	0.0	0.1	2.8	2.78	.F.

Table 4.4 Watershed and pond statistics for the Lunty site

Shed No.	Shed Area	Pit Row	Pit Col	Pit Elev	Pit Voll	Pit Area	Drains To	Pit Row	In Col	In Elev	Out Row	Out Col	Out Elev	Pour Elev	Next Pit	Row 2	Col 2	Volto Flood	Prev Vol	Total Vol	V/A Ratio	mm to Flood	Edge Pit?
96	17	151	14	725.2	0.2	2	103	151	13	725.3	152	12	725.2	725.3	93	149	17	0.2	0.0	0.2	11.8	11.76	.F.
97	52	151	73	724.8	0.2	2	88	148	73	724.9	147	73	724.9	724.9	136	147	73	0.2	0.0	0.2	3.8	3.85	.F.
98	13	151	77	724.4	0.1	1	99	151	78	724.5	150	79	724.4	724.5	99	150	79	0.1	0.0	0.1	7.7	7.69	.F.
99	70	151	80	724.2	0.1	1	107	152	81	724.3	153	82	724.3	724.3	107	153	82	0.1	0.0	0.1	1.4	1.43	.F.
100	95	151	103	725.5	0.7	7	83	147	100	725.6	147	99	725.6	725.6	83	147	99	0.7	0.0	0.7	7.4	7.37	.F.
101	195	152	64	725.7	0.2	2	102	148	64	725.8	149	65	725.8	725.8	102	149	65	0.2	0.0	0.2	1.0	1.03	.F.
102	471	152	70	725.1	1.7	11	97	149	70	725.1	148	71	725.3	725.3	97	148	71	1.7	0.0	1.7	3.6	3.61	.F.
103	151	153	10	725.1	0.8	7	93	148	14	725.3	147	14	725.3	725.3	96	149	14	0.8	0.0	0.8	5.3	5.30	.F.
104	125	154	110	725.4	0.4	4	114	155	110	725.5	156	111	725.5	725.5	114	156	111	0.4	0.0	0.4	3.2	3.20	.F.
105	67	155	5	725.3	0.1	1	103	156	6	725.4	155	7	725.3	725.4	141	155	7	0.1	0.0	0.1	1.5	1.49	.F.
106	67	155	85	724.2	0.2	2	109	156	85	724.3	157	86	724.2	724.3	109	157	86	0.2	0.0	0.2	3.0	2.99	.F.
107	37	156	83	724.2	0.2	2	106	153	82	724.3	154	83	724.3	724.3	106	154	83	0.2	0.0	0.2	5.4	5.41	.F.
108	16	159	52	726.8	0.1	1	112	159	52	726.8	159	51	726.9	726.9	112	159	51	0.1	0.0	0.1	6.2	6.25	.T
109	111	159	86	724.2	0.3	3	109	157	85	724.3	156	85	724.3	724.3	109	156	85	0.3	0.0	0.3	2.7	2.70	.T
110	280	159	140	725.8	0.0	90	74	144	140	726.4	143	140	726.4	726.4	110	143	140	25.5	0.0	25.5	0.0	91.07	.T
111	165	160	37	725.7	0.0	19	112	160	38	725.9	160	39	725.8	725.9	111	160	39	3.1	0.0	3.1	0.0	18.79	.T
112	90	160	39	725.8	0.0	1	111	159	39	725.9	160	38	725.9	725.9	112	160	38	0.1	0.0	0.1	0.0	1.11	.T
113	12	160	96	725.3	0.0	1	109	160	96	725.3	160	95	725.4	725.4	109	160	95	0.0	0.0	0.0	0.0	8.33	.T
114	103	160	110	724.9	0.0	2	115	160	111	725.0	160	112	724.9	725.0	114	160	112	0.2	0.0	0.2	0.0	1.94	.T
115	66	160	112	724.9	0.0	1	114	160	112	724.9	160	111	725.0	725.0	115	160	111	0.0	0.0	0.0	0.0	1.52	.T
116	1207	65	78	721.7	7.3	275	37	63	80	721.9	64	81	721.9	721.9	118	64	81	5.8	1.8	7.6	4.2	7.46	.F.
117	1272	66	72	721.5	32.8	168	39	66	65	722.0	67	65	722.0	722.0	119	67	65	32.6	1.5	34.1	14.3	26.81	.F.
118	1756	65	78	721.7	109.5	275	21	50	89	722.4	49	90	722.3	722.4	120	49	90	102.2	7.7	109.9	62.5	65.66	.F.
119	1696	66	72	721.5	159.4	405	41	72	73	722.4	73	73	733.4	722.4	121	73	73	126.6	34.3	160.9	91.6	81.91	.F.
120	2991	65	78	721.7	157.8	483	29	59	76	722.5	59	75	722.5	722.5	124	59	75	48.3	131.7	180.0	60.2	81.80	.F.
121	1900	66	72	721.5	207.0	476	35	57	75	722.5	58	76	722.5	722.5	124	58	76	47.6	161.0	208.6	109.8	98.63	.F.
122	797	89	16	722.7	4.8	41	61	92	14	722.9	93	14	722.9	722.9	125	93	14	4.1	0.9	5.0	6.3	6.28	.F.
123	253	75	8	722.7	4.3	30	32	66	12	722.9	65	12	722.9	722.9	32	65	12	3.0	1.6	4.6	18.2	12.77	.F.
124	4891	66	72	721.5	735.3	1541	23	54	50	722.9	55	49	722.9	722.9	128	53	49	528.3	388.6	916.9	187.5	206.65	.F.
125	905	89	16	722.7	13.7	89	60	92	13	723.0	93	12	723.0	723.0	60	93	12	8.9	5.2	14.1	15.6	15.58	.F.
126	1146	75	8	722.7	14.2	99	49	79	7	723.0	80	6	723.0	723.0	38	68	13	9.9	5.2	15.1	13.2	27.13	.F.
127	1216	75	8	722.7	31.9	177	54	78	12	723.1	79	12	723.1	723.1	54	79	12	17.7	15.3	33.0	16.8	18.14	.F.
128	6251	66	72	721.5	1309.1	2049	52	83	68	723.2	84	68	723.2	723.2	130	84	68	573.8	924.4	1498.2	239.7	298.94	.F.
129	1683	98	61	722.9	38.7	163	52	86	65	723.3	86	66	723.3	723.3	131	86	66	28.3	10.5	38.8	23.1	23.30	.F.
130	6274	66	72	721.5	1527.2	2181	55	86	66	723.3	87	65	723.2	723.3	131	87	65	218.0	1498.3	1716.3	273.6	333.69	.F.
131	7957	66	72	721.5	2342.1	2889	42	73	96	723.6	74	97	723.5	723.6	132	74	97	815.0	1755.1	2570.1	323.0	436.08	.F.
132	8149	66	72	721.5	3674.2	3595	5	21	92	724.0	20	91	723.9	724.0	5	20	91	1332.1	2570.2	3902.3	478.7	596.16	.F.
133	663	111	115	723.8	6.1	37	67	108	108	724.1	107	107	724.0	724.1	134	107	107	5.9	0.4	6.3	9.5	9.51	.F.
134	1083	111	115	723.8	13.2	71	66	107	116	724.4	106	115	724.2	724.4	137	106	115	7.1	7.0	14.1	12.2	13.02	.F.
135	879	139	98	724.9	7.7	71	82	135	91	725.1	136	90	725.0	725.1	139	136	90	7.1	2.1	9.2	10.5	10.48	.F.
136	176	144	73	724.8	5.2	32	91	140	74	725.0	141	75	725.1	725.1	91	141	75	4.7	0.7	5.4	30.7	8.86	.F.
137	1104	111	115	723.8	183.7	279	37	95	102	725.1	94	101	725.0	725.1	37	94	101	170.5	14.3	184.8	167.4	167.45	.F.
138	749	149	24	725.0	11.1	66	96	148	17	725.3	149	16	725.3	725.3	87	143	19	10.6	1.0	11.6	15.5	15.48	.F.
139	927	139	98	724.9	47.9	148	99	144	88	725.4	145	87	725.4	725.4	99	145	87	40.2	10.0	50.2	54.2	48.21	.F.
140	934	149	24	725.0	26.6	155	85	141	18	725.4	141	17	725.4	725.4	105	155	5	15.5	12.7	28.2	30.2	33.89	.F.
141	1137	149	24	725.0	108.2	309	81	137	18	725.7	136	19	725.6	725.7	142	136	19	81.6	28.7	110.3	97.0	106.10	.F.
142	1289	149	24	725.0	184.1	399	79	135	12	725.9	134	11	725.8	725.9	63	130	5	75.9	111.4	187.3	145.3	165.83	.F.
143	443	93	119	726.9	13.7	118	24	75	120	727.1	74	121	727.0	727.1	24	74	121	11.8	3.2	15.0	33.9	33.86	.F.
144	1981	13	140	721.2	6.1	37	9	8	136	721.5	7	135	721.4	721.5	145	7	135	6.0	0.3	6.3	3.2	3.20	.F.
145	2021	13	140	721.2	30.4	97	10	10	131	721.8	9	131	721.8	721.8	10	9	131	24.3	6.6	30.9	15.3	15.30	.T

Table 5.1 Identification and recognition of contributions made to the development of the model

Contribution made to development of the model	**Individual(s)**
Assistance with developing the initial concept of focusing on the relatively stable and defineable landscape feature of "depressional storage"	S. R. Moran, R.W. Howitt Alberta Research Council
Assistance with examining approaches for dealing with the hierarchical structure of "nested" ponding	R. G. Healey, P. A. Furley University of Edinburgh
Provision of interactive program "Watersh" used to establish cell to cell flow connectivity.	W. P. A. van Deursen University of Utrecht
Assistance with revision of the "Watersh" utilities to provide data on pond location, size, volume and overspill locations (pour points).	W. P. A. van Deursen, University of Utrecht
Provision of GIS utilities (PC-Geostat) for editing, manipulation and display of raster data	P. A. Burrough, W. P. A. van Deursen, University of Utrecht
Provision of source code for the evapo-transpiration equations utilized by the model SWATRE and assistance with understanding these equations and adapting them for use in the present model	J. A. Wesseling & B. J. van den Broek, Staring Centre, Wengeningen, the Netherlands
Provision of source code for energy balance snowmelt model and assistance with understanding the code and adapting it for use in the present model	L. W. Williams, University of Edinburgh
Provision of ANSWERS manual and source code from which the numerous concepts and algorithms were extracted for use in the present model.	D. B. Beasley.

Table 6.1 Summary of the intended goal and the assigned parameter values for each of the 10 runs of the DISTHMOD model.

Run No.	Reason for run	Soil File	Maximum Steady State Infiltration Rate (mm/hr)			Evaporation Approach		Surface Retention (mm)	Initial Snow Depth (mm)	Julian Day No. Soil First Thaws		
			Store S1	Store S2	Store S3	on/off	Method	Max Depth	Mean Depth	S1	S2	S3
1	Simulate maximum runoff conditions	Soil 1	0	0	0	off	Penman	0	400	166	166	166
2	Simulate minimum runoff conditions	Soil 2	15	5	6	on	Penman	50	400	81	81	81
3	Determine if losses from evaporation alone can account for pond decay	Soil 1	0	0	0	on	Penman	20	400	166	166	166
4	Determine if evaporation and infiltration at full rates will simulate pond formation and reduction	Soil 3	4.9	6.9	1.8	on	Penman	20	400	81	81	81
5	Simulate effect of permitting full evaporation at all times but infiltration only after soil has thawed	Soil 3	4.9	6.9	1.8	on	Penman	20	400	102	112	122
6	Investigate effect of assigning an initial depth of snow based on mean snow depth at snow survey sites.	Soil 3	4.9	6.9	1.8	on	Penman	20	130	102	112	122
7	Investigate if variable depth of snow produced by regression equation produces better estimates of runoff.	Soil 3	1.5	2.3	1.0	on	Penman	20	75	102	112	122
8	Investigate if adjustment of regression equation to estimate mean snow depth of 20 cm improves predictions.	Soil 4	1.5	2.3	1.0	on	Penman	20	200	95	95	95
9	Investigate effect of assigning a variable depth of snow (mean of 15 cm) and permitting infiltration at low rates after April 5, 1989.	Soil 4	1.5	2.3	1.0	on	Penman	20	150	95	95	95
10	Investigate relative sensitivity of model to evaporation by redoing run 9 with infiltration turned off.	Soil 1	0	0	0	on	Penman	20	150	95	95	95

Table 6.2 An extract from the file LuntyGRD illustrating the structure and content of the reformatted GRIDDATA dBase III+® file

Row	Col	Elev	DDIR	DREC	Shed No.	Shed Order	Upslope Area	FLODVOL
30	140	723.5	8	4060	13	114	203	9999.99
31	1	724.3	8	4061	17	71	13	7.10
31	2	724.3	8	4062	17	71	18	7.10
31	3	724.3	8	4063	17	71	16	7.10
31	4	724.4	7	4063	17	71	19	11.20
31	5	724.5	4	4204	17	71	18	16.10
31	6	724.6	4	4205	17	71	17	22.40
31	7	724.7	4	4206	17	71	2	30.00
31	8	724.8	4	4207	17	71	1	9999.99
31	9	724.7	2	4349	17	71	9	30.00
31	10	724.8	4	4209	17	71	6	9999.99
31	11	724.9	4	4210	17	71	1	9999.99
31	12	724.9	2	4352	30	87	5	9999.99
31	13	724.9	2	4353	30	87	2	9999.99
31	14	724.9	1	4353	30	87	26	9999.99
31	15	725.0	4	4214	30	87	1	9999.99
31	16	725.0	1	4355	30	87	4	9999.99
31	17	725.1	2	4357	30	87	19	9999.99
31	18	725.1	2	4358	30	87	1	9999.99
31	19	725.2	1	4358	30	87	1	9999.99
31	20	725.2	2	4360	30	87	2	9999.99
31	21	725.2	1	4360	30	87	4	9999.99
31	22	725.2	3	4363	23	91	11	9999.99
31	23	725.2	2	4363	23	91	1	9999.99
31	24	725.2	3	4365	23	91	1	9999.99
31	25	725.1	3	4366	23	91	16	9999.99
31	26	725.1	2	4366	23	91	1	9999.99
31	27	725.0	1	4366	23	91	3	9999.99
31	28	725.0	3	4369	23	91	1	9999.99
31	29	724.9	2	4369	23	91	14	9999.99
31	30	724.9	3	4371	23	91	1	9999.99
31	31	724.7	3	4372	23	91	2	9999.99
31	32	724.5	3	4373	23	91	12	9999.99
31	33	724.4	3	4374	23	91	3	9999.99
31	34	724.2	6	4235	23	91	2	9999.99
31	35	723.9	3	4376	23	91	3	3542.69
31	36	723.7	6	4237	23	91	9	2876.69
31	37	723.5	3	4378	23	91	11	2281.24
31	38	723.4	2	4378	23	91	16	2008.64
31	39	723.3	1	4378	23	91	329	1716.38
31	40	723.4	2	4380	23	91	74	2008.64
31	41	723.5	1	4380	23	91	1	2281.24
31	42	723.7	1	4381	23	91	1	2876.69
31	43	723.8	1	4382	23	91	26	3200.19
31	44	724.0	4	4243	23	91	25	3902.19
31	45	724.1	4	4244	23	91	24	9999.99

Table 6.3 An extract from the GRIDDATA file LuntyGRD illustrating the effect on record order imposed by the index TOPDOWN

ROW	COL	ELEV	DDIR	DREC	SHEDNO	SHEDORD	UPSLOPE	FLODVOL
63	74	721.9	4	8753	36	110	2	17.30
66	74	721.9	4	9173	36	110	2	17.30
67	74	721.9	4	9313	36	110	2	17.30
68	74	721.9	4	9453	36	110	2	17.30
69	73	721.9	8	9453	36	110	10	17.30
69	71	721.9	8	9451	36	110	17	17.30
68	71	721.9	9	9312	36	110	18	17.30
62	73	721.8	2	8753	36	110	1	6.60
64	73	721.8	4	8892	36	110	1	6.60
65	70	721.8	6	9031	36	110	1	6.60
65	73	721.8	1	9172	36	110	1	6.60
64	74	721.8	7	8753	36	110	2	6.60
65	74	721.8	1	9173	36	110	2	6.60
67	73	721.8	7	9172	36	110	3	6.60
66	73	721.8	4	9172	36	110	5	6.60
68	73	721.8	7	9312	36	110	16	6.60
64	71	721.7	2	9031	36	110	1	0.20
65	72	721.7	2	9172	36	110	1	0.20
63	73	721.7	1	8892	36	110	8	0.20
64	72	721.7	1	9031	36	110	10	0.20
65	71	721.7	3	9172	36	110	14	0.20
67	72	721.7	8	9172	36	110	36	0.20
66	72	721.5	5	9172	36	110	63	0.01
49	75	722.8	4	6794	26	111	1	762.80
50	75	722.7	4	6934	26	111	1	623.60
51	75	722.7	4	7074	26	111	1	623.60
52	75	722.7	4	7214	26	111	1	623.60
53	75	722.7	4	7354	26	111	1	623.60
54	75	722.6	4	7494	26	111	1	498.60
55	75	722.6	4	7634	26	111	1	498.60
56	75	722.6	4	7774	26	111	1	498.60
57	75	722.5	4	7914	26	111	1	208.61
58	75	722.5	7	7914	26	111	1	208.61
58	74	722.2	4	8053	26	111	1	84.90
49	74	722.1	1	6933	26	111	2	56.80
50	74	722.1	1	7073	26	111	2	56.80
54	74	722.1	4	7493	26	111	2	56.80
55	74	722.1	4	7633	26	111	2	56.80
49	73	722.0	2	6933	26	111	1	34.10
51	74	722.0	4	7073	26	111	2	34.10
52	74	722.0	1	7353	26	111	2	34.10
54	72	721.9	6	7493	26	111	1	17.30
53	74	721.9	4	7353	26	111	2	17.30
56	74	721.9	4	7773	26	111	2	17.30
57	74	721.9	7	7773	26	111	3	17.30
50	73	721.9	2	7073	26	111	4	17.30
52	73	721.8	2	7353	26	111	1	6.60
53	72	721.8	6	7353	26	111	1	6.60

Table 6.4 Total daily volume of melt water estimated for reference depths from 5 to 70 cm for the Lunty site for spring, 1989

Month	Day	Julian Day	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
March	22	81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	10.94	12.05	7.45	4.94	1.67	0.00	0.00	0.00	0.00
March	24	83	0.00	9.96	14.05	9.87	7.08	5.03	1.94	0.00	0.00
March	25	84	0.00	0.00	2.22	0.12	0.00	0.00	0.00	0.00	0.00
March	26	85	0.00	0.00	3.32	0.11	0.00	0.00	0.00	0.00	0.00
March	27	86	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	0.00	0.00	5.87	0.42	0.00	0.00	0.00	0.00	0.00
March	29	88	0.00	0.00	0.00	10.08	6.26	5.02	4.13	2.75	0.00
March	30	89	0.00	0.00	0.00	18.43	11.62	9.39	8.28	7.52	6.64
March	31	90	0.00	0.00	0.00	0.00	14.46	11.61	10.51	9.79	9.30
April	1	91	0.00	0.00	0.00	0.00	20.79	11.95	10.32	9.46	8.90
April	2	92	0.00	0.00	0.00	0.00	4.11	10.50	8.38	7.35	6.68
April	3	93	0.00	0.00	0.00	0.00	0.00	5.40	3.08	1.93	1.33
April	4	94	0.00	0.00	0.00	0.00	0.00	20.12	13.35	11.75	10.96
April	5	95	0.00	0.00	0.00	0.00	0.00	8.98	4.91	3.38	2.59
April	6	96	0.00	0.00	0.00	0.00	0.00	0.00	6.79	4.64	3.60
April	7	97	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.05	0.00
April	8	98	0.00	0.00	0.00	0.00	0.00	0.00	6.40	3.01	1.93
April	9	99	0.00	0.00	0.00	0.00	0.00	0.00	13.74	8.48	7.13
April	10	100	0.00	0.00	0.00	0.00	0.00	0.00	17.33	9.56	7.49
April	11	101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.40	14.73
April	12	102	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.95	33.40
April	13	103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.73
April	14	104	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.58
April	15	105	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6.5 Summary of soil hydrological property values assigned to the five main soils for the various runs of DISTHMOD

Data Base	SOIL	FC 1	TP 1	FP 1	WP 1	Depth 1	Vol TP1	Vol FP1	Vol WP1	GWC 1	FC 2	TP 2	FP 2	Depth 2	Vol TP2	Vol FP2	GWC 2	FC 3	TP 3	FP 3	Depth 3	Vol TP3	Vol FP3	GWC 3	S1 %	S2 %	S3 %	S1 Vol	S2 Vol	S3 Vol
SOIL1	1	0.0	58	34	12	250	0	0	0	0	0.0	43	24	250	0	0	0	0.0	42	33	500	0	0	0	30	32	37	75	80	185
SOIL1	2	0.0	59	34	12	120	0	0	0	0	0.0	43	29	150	0	0	0	0.0	40	22	730	0	0	0	34	34	36	41	51	263
SOIL1	3	0.0	59	20	16	220	0	0	0	0	0.0	45	30	230	0	0	0	0.0	43	21	550	0	0	0	29	30	34	64	69	187
SOIL1	4	0.0	55	22	8	180	0	0	0	0	0.0	43	23	320	0	0	0	0.0	42	20	500	0	0	0	29	24	23	52	77	115
SOIL1	5	0.0	51	28	14	120	0	0	0	0	0.0	45	28	280	0	0	0	0.0	43	20	600	0	0	0	23	24	20	28	67	120
SOIL1	8	0.0	40	40	30	200	0	0	0	0	0.0	40	40	200	0	0	0	0.0	40	30	600	0	0	0	40	40	40	80	80	240
SOIL2	1	15.0	58	34	12	250	145	85	30	60	5.0	43	24	250	108	60	48	3.0	42	33	500	210	165	45	30	32	37	75	80	185
SOIL2	2	15.0	59	34	12	120	71	41	14	30	5.0	43	29	150	64	44	21	3.0	40	22	730	292	161	131	34	34	36	41	51	263
SOIL2	3	15.0	59	20	16	220	130	44	35	86	5.0	45	30	230	104	69	34	5.0	43	21	550	236	116	121	29	30	34	64	69	187
SOIL2	4	15.0	55	22	8	180	99	40	14	59	5.0	43	23	320	138	74	64	5.0	42	20	500	210	100	110	29	24	23	52	77	115
SOIL2	5	15.0	51	28	14	120	61	34	17	28	5.0	45	28	280	126	78	48	5.0	43	20	600	258	120	138	23	24	20	28	67	120
SOIL2	8	0.1	40	40	30	200	80	80	60	0	0.1	40	40	200	80	80	0	0.1	40	30	600	240	180	60	40	40	40	80	80	240
SOIL3	1	2.7	58	34	12	250	145	85	30	60	0.2	43	24	250	108	60	48	0.8	42	33	500	210	165	45	30	32	37	75	80	185
SOIL3	2	2.4	59	34	12	120	71	41	14	30	0.5	43	29	150	64	44	21	0.6	40	22	730	292	161	131	34	34	36	41	51	263
SOIL3	3	2.4	59	20	16	220	130	44	35	86	0.4	45	30	230	104	69	34	1.8	43	21	550	236	116	121	29	30	34	64	69	187
SOIL3	4	4.9	55	22	8	180	99	40	14	59	1.1	43	23	320	138	74	64	1.8	42	20	500	210	100	110	29	24	23	52	77	115
SOIL3	5	4.5	51	28	14	120	61	34	17	28	6.9	45	28	280	126	78	48	1.8	43	20	600	258	120	138	23	24	20	28	67	120
SOIL3	8	0.1	40	40	30	200	80	80	60	0	0.1	40	40	200	80	80	0	0.1	40	30	600	240	180	60	40	40	40	80	80	240
SOIL4	1	0.1	58	12	12	250	145	30	30	115	0.1	43	12	250	108	30	78	0.5	42	17	500	210	85	125	30	32	37	75	80	185
SOIL4	2	0.1	59	12	12	120	71	14	14	57	0.2	43	14	150	64	21	43	0.1	40	14	730	292	102	190	34	34	36	41	51	263
SOIL4	3	1.5	59	16	16	220	130	35	35	95	0.2	45	14	230	104	32	72	1.0	43	8	550	236	44	192	29	30	34	64	69	187
SOIL4	4	1.5	55	8	8	180	99	14	14	85	0.1	43	20	320	138	64	74	1.0	42	12	500	210	60	150	29	24	23	52	77	115
SOIL4	5	1.5	51	14	14	120	61	17	17	44	2.3	45	13	280	126	36	90	1.0	43	12	600	258	72	186	23	24	20	28	67	120
SOIL4	8	0.1	40	40	30	200	80	80	60	0	0.1	40	40	200	80	80	0	0.1	40	30	600	240	180	60	40	40	40	80	80	240

Table 6.6 Comparison of pan evaporation recorded at approximately weekly intervals during the spring of 1989 and potential evaporation computed by the 5 SWATRE equations

MONTH	DAY	PENMAN	MONTEITH	PRIESTLY	MAKKINK	RITCHIE	PAN EVAP	0.7 PAN
March	23	1.24	1.04	1.00	4.04	0.74	0.00	0.0
March	29	3.04	2.62	2.99	6.60	2.21	0.00	0.0
March	31	5.72	4.63	6.25	4.54	4.63	0.00	0.0
April	5	10.72	9.11	11.51	8.55	8.53	8.00	5.6
April	13	26.44	19.62	25.63	19.23	18.99	21.20	14.8
April	20	30.05	20.32	28.41	20.69	21.04	27.80	19.5
April	27	20.08	16.24	20.21	15.41	14.97	23.30	16.3
May	3	23.85	17.38	21.05	16.06	15.59	29.60	20.7
May	10	38.27	25.31	31.41	23.19	23.27	50.60	35.4
May	15	20.52	14.78	18.17	13.61	13.46	38.40	26.9
May	17	7.27	5.38	6.11	4.54	4.52	7.70	5.4
May	24	17.29	11.66	15.34	11.55	11.36	32.20	22.5
May	31	30.38	22.70	28.88	21.45	21.39	31.90	22.3
June	6	32.78	25.17	31.40	22.85	23.26	44.40	31.1
June	15	35.38	25.41	33.34	24.05	24.69	89.70	62.8

Table 7.1 Comparison of simulated pond volume, area and depth to field data for pond 185-East.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		1032.5	723.6	693.5	521.5	284.8	155.6	148.3	140.9		155.6
Run 1	1922.9	14259.8	17825.5	17825.5	18441.1	18612.5	18903.1	19055.2	22333.1	22539.9	29132.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	969.8	9836.3	12508.3	11700.9	11256.7	10493.7	4421.7	4098.4	4429.1	4022.6	4490.9
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	969.7	9836.7	10911.7	10113.3	4202.8	3750.1	2491.7	2073.4	1868.3	1422.7	910.0
Run 6	1118.0	1067.7	713.5	589.7	416.7	305.9	139.7	53.5	30.8	14.5	0.0
Run 7	430.9	453.4	309.8	221.9	137.3	85.8	23.6	1.7	0.7	0.0	0.0
Run 8	1524.5	1776.3	1432.7	1226.8	1071.9	859.4	628.8	455.6	442.6	281.3	193.3
Run 9	987.2	1065.0	700.8	504.9	404.8	270.6	147.7	85.4	105.0	36.2	82.5
Run 10	987.2	1065.0	1067.2	920.4	853.9	735.8	759.2	473.3	735.1	591.0	1202.4
Pond Area (m2)											
Field		5125.0	4300.0	4300.0	4300.0	3075.0	1475.0	1475.0	1475.0		1475.0
Run 1	6175.0	31250.0	34800.0	34800.0	34800.0	34800.0	34800.0	34800.0	38525.0	38525.0	47850.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	5125.0	14400.0	31250.0	14400.0	14400.0	14400.0	7975.0	7975.0	7975.0	7975.0	7975.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	5125.0	14400.0	14400.0	14400.0	7975.0	7975.0	6875.0	6875.0	6175.0	5125.0	4300.0
Run 6	5125.0	5125.0	4300.0	4300.0	2825.0	2825.0	1475.0	1475.0	475.0	475.0	0.0
Run 7	2825.0	2825.0	2825.0	2825.0	1475.0	1475.0	475.0	475.0	25.0	0.0	0.0
Run 8	6175.0	6175.0	5125.0	5125.0	5125.0	4300.0	4300.0	2825.0	2825.0	2825.0	2825.0
Run 9	5125.0	5125.0	4300.0	4300.0	2825.0	2825.0	1700.0	1700.0	1700.0	475.0	1700.0
Run 10	5125.0	5125.0	5125.0	4300.0	4300.0	4300.0	4300.0	2825.0	4300.0	4300.0	5125.0
Pond Depth (m)											
Field		0.42	0.36	0.35	0.31	0.23	0.18	0.17	0.17		0.18
Run 1	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.10	1.30
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.40	0.80	0.90	0.80	0.80	0.80	0.70	0.70	0.70	0.70	0.70
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.40	0.80	0.80	0.80	0.70	0.70	0.60	0.60	0.50	0.40	0.30
Run 6	0.40	0.40	0.30	0.30	0.20	0.20	0.10	0.10	0.01	0.01	0.00
Run 7	0.20	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.00	0.00
Run 8	0.50	0.50	0.40	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.20
Run 9	0.40	0.40	0.30	0.30	0.20	0.20	0.10	0.10	0.10	0.01	0.10
Run 10	0.40	0.40	0.40	0.30	0.30	0.30	0.30	0.20	0.30	0.30	0.40

Table 7.2 Comparison of simulated pond volume, area and depth to field data for pond 185-West.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		1560.5	1138.8	1110.6	885.6	560.0	365.7	352.3	338.9		365.6
Run 1	2367.8	14259.8	17825.5	17825.5	18441.1	18612.5	18903.1	19055.2	22333.1	22539.9	29132.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	1390.5	9836.3	12508.3	11700.9	11256.7	10493.7	5086.8	4768.9	5030.9	4630.0	5206.1
Run 4	0.0	3.9	2.2	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	1390.8	9836.7	10911.7	10113.3	4802.6	4368.6	3595.3	2985.6	2705.5	2070.0	1380.9
Run 6	1534.1	1465.1	1030.4	868.3	667.5	515.4	293.8	150.5	111.1	32.5	3.9
Run 7	654.4	664.9	394.2	317.9	196.3	135.0	46.0	20.6	11.4	3.6	2.5
Run 8	2414.2	3017.7	2229.8	1883.6	1652.7	1358.5	1057.1	819.6	795.6	157.5	441.0
Run 9	1460.2	1532.1	1005.9	765.6	620.8	436.8	289.8	174.9	190.3	112.3	148.8
Run 10	1460.2	1532.1	1474.9	1300.9	1203.9	1049.6	857.5	730.5	1022.5	831.1	1700.0
Pond Area (m2)											
Field		7025.0	5625.0	5625.0	5625.0	4250.0	2675.0	2675.0	2675.0		2675.0
Run 1	8875.0	31250.0	34800.0	34800.0	34800.0	34800.0	34800.0	34800.0	38525.0	38525.0	51225.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	5500.0	13100.0	31250.0	13100.0	13100.0	13100.0	11850.0	11850.0	11850.0	11850.0	11850.0
Run 4	0.0	350.0	350.0	350.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	5500.0	13100.0	13100.0	13100.0	11850.0	11850.0	10125.0	10125.0	10125.0	7025.0	5500.0
Run 6	7025.0	7025.0	5500.0	5500.0	4200.0	4200.0	2675.0	1275.0	1275.0	350.0	350.0
Run 7	4200.0	4200.0	2675.0	2675.0	2675.0	1275.0	1275.0	1275.0	350.0	350.0	350.0
Run 8	8875.0	10125.0	8875.0	7025.0	7025.0	5500.0	5500.0	4200.0	4200.0	1275.0	4200.0
Run 9	7025.0	7025.0	5500.0	4200.0	4200.0	4200.0	2675.0	2675.0	2675.0	1275.0	1275.0
Run 10	7025.0	7025.0	7025.0	5500.0	5500.0	5500.0	5500.0	4200.0	5500.0	4200.0	7025.0
Pond Depth (m)											
Field		0.62	0.55	0.55	0.51	0.43	0.38	0.37	0.37		0.37
Run 1	0.60	1.00	1.10	1.10	1.10	1.10	1.10	1.10	1.20	1.20	1.50
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.40	0.90	1.00	0.90	0.90	0.90	0.80	0.80	0.80	0.80	0.80
Run 4	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.40	0.90	0.90	0.90	0.80	0.80	0.70	0.70	0.70	0.50	0.40
Run 6	0.50	0.50	0.40	0.40	0.30	0.30	0.20	0.10	0.10	0.01	0.01
Run 7	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.10	0.01	0.01	0.01
Run 8	0.60	0.70	0.60	0.50	0.50	0.40	0.40	0.30	0.30	0.10	0.30
Run 9	0.50	0.50	0.40	0.30	0.30	0.30	0.20	0.20	0.20	0.10	0.10
Run 10	0.50	0.50	0.50	0.40	0.40	0.40	0.40	0.30	0.40	0.30	0.50

Table 7.3 Comparison of simulated pond volume, area and depth to field data for pond 184.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		581.9	394.9	246.7	180.3	123.9	81.4	42.1	40.1		111.2
Run 1	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0	545.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	545.0	545.0	545.0	545.0	545.0	545.0	458.2	297.9	240.5	134.8	49.7
Run 6	532.1	506.6	310.6	255.9	188.6	135.5	74.7	38.4	25.9	7.8	0.0
Run 7	311.8	307.8	179.3	134.8	95.4	64.4	28.1	9.6	6.2	0.0	0.0
Run 8	545.0	545.0	300.8	227.3	176.8	121.8	75.7	45.6	50.2	29.0	43.0
Run 9	545.0	540.6	293.2	218.9	168.1	118.0	71.9	43.3	49.8	28.6	42.9
Run 10	545.0	540.6	501.9	433.8	380.0	308.3	243.3	204.6	354.4	279.0	498.3
Pond Area (m2)											
Field		4100.0	2600.0	1475.0	1475.0	850.0	850.0	400.0	400.0		850.0
Run 1	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	4100.0	4100.0	4100.0	4100.0	4100.0	4100.0	2600.0	2600.0	1475.0	850.0	400.0
Run 6	2600.0	2600.0	2600.0	1475.0	1475.0	850.0	850.0	400.0	400.0	125.0	0.0
Run 7	2600.0	2600.0	1475.0	850.0	850.0	850.0	400.0	125.0	125.0	0.0	0.0
Run 8	4100.0	4100.0	2600.0	1475.0	1475.0	850.0	850.0	400.0	400.0	400.0	400.0
Run 9	4100.0	2600.0	2600.0	1475.0	1475.0	850.0	850.0	400.0	400.0	400.0	400.0
Run 10	4100.0	2600.0	2600.0	2600.0	2600.0	2600.0	1475.0	1475.0	2600.0	1475.0	2600.0
Pond Depth (m)											
Field		0.51	0.44	0.37	0.33	0.28	0.23	0.17	0.17		0.27
Run 1	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.50	0.50	0.50	0.50	0.50	0.50	0.40	0.40	0.30	0.20	0.10
Run 6	0.40	0.40	0.40	0.30	0.30	0.20	0.20	0.10	0.10	0.01	0.00
Run 7	0.40	0.40	0.30	0.20	0.20	0.20	0.10	0.01	0.01	0.00	0.00
Run 8	0.50	0.50	0.40	0.30	0.30	0.20	0.20	0.10	0.10	0.10	0.10
Run 9	0.50	0.40	0.40	0.30	0.30	0.20	0.20	0.10	0.10	0.10	0.10
Run 10	0.50	0.40	0.40	0.40	0.40	0.40	0.30	0.30	0.40	0.30	0.40

Table 7.4 Comparison of simulated pond volume, area and depth to field data for pond 155.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field	847.8	652.2	487.5	337.5	200.4						367.5
Run 1	970.0	970.0	970.0	970.0	970.0	970.0	970.0	970.0	970.0	970.0	970.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	810.8	970.0	902.3	784.0	710.0	596.9	477.9	397.8	588.4	477.2	894.4
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	810.8	970.0	657.8	543.3	405.1	295.8	148.5	63.9	37.0	0.0	0.0
Run 6	886.3	846.0	535.0	448.2	310.0	221.4	95.9	37.5	10.0	0.0	0.0
Run 7	400.3	406.4	202.9	151.9	78.9	47.9	0.0	0.0	0.0	0.0	0.0
Run 8	970.0	970.0	587.7	443.6	339.1	225.2	130.3	69.9	71.1	25.8	28.6
Run 9	835.8	881.2	374.1	366.2	261.6	184.0	89.0	49.2	55.9	10.6	23.3
Run 10	835.8	881.2	821.7	703.4	629.4	525.8	416.1	336.1	536.4	435.3	868.7
Pond Area (m2)											
Field	4075.0	4075.0	3000.0	3000.0	1775.0						3000.0
Run 1	4725.0	4725.0	4725.0	4725.0	4725.0	4725.0	4725.0	4725.0	4725.0	4725.0	4725.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	4075.0	4725.0	4075.0	4075.0	4075.0	4075.0	3000.0	3000.0	4075.0	3000.0	4075.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	4075.0	4725.0	4075.0	3000.0	3000.0	3000.0	1775.0	850.0	850.0	0.0	0.0
Run 6	4075.0	4075.0	3000.0	3000.0	3000.0	1775.0	1775.0	850.0	850.0	0.0	0.0
Run 7	3000.0	3000.0	1775.0	1775.0	875.0	875.0	0.0	0.0	0.0	0.0	0.0
Run 8	4725.0	4725.0	4075.0	3000.0	3000.0	1775.0	1775.0	850.0	850.0	850.0	850.0
Run 9	4075.0	4075.0	4075.0	3000.0	1775.0	1775.0	1775.0	850.0	850.0	850.0	850.0
Run 10	4075.0	4075.0	4075.0	4075.0	4075.0	3000.0	3000.0	3000.0	3000.0	3000.0	4075.0
Pond Depth (m)											
Field	0.37	0.32	0.28	0.23	0.17						0.24
Run 1	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.30	0.40	0.30	0.30	0.30	0.30	0.20	0.20	0.30	0.20	0.30
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.30	0.40	0.30	0.20	0.20	0.20	0.10	0.01	0.01	0.00	0.00
Run 6	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.00	0.00
Run 7	0.20	0.20	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 8	0.40	0.40	0.30	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.01
Run 9	0.30	0.30	0.30	0.20	0.10	0.10	0.10	0.01	0.01	0.01	0.01
Run 10	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20	0.30

Table 7.5 Comparison of simulated pond volume, area and depth to field data for pond 157.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		369.7	267.5	172.3	156.5	36.5	30.5	11.3	11.3		6.3
Run 1	855.6	2365.7	2780.0	2780.0	2875.7	2907.5	2949.0	2974.5	3478.4	3510.3	4498.9
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	527.6	1665.3	1865.1	1731.8	1654.5	1538.5	1384.7	1275.0	1405.1	1267.2	1462.7
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	527.8	1665.4	1591.1	1469.5	1277.3	1138.8	876.5	690.9	593.5	418.5	219.2
Run 6	575.0	551.6	368.2	309.3	228.7	149.5	96.0	50.4	32.7	8.8	1.7
Run 7	180.4	157.0	127.0	113.4	72.4	50.0	13.0	5.6	3.8	1.1	0.0
Run 8	1198.8	1301.7	950.0	801.1	696.3	568.1	437.8	339.2	326.6	233.5	176.1
Run 9	565.9	597.3	256.4	288.1	227.2	161.3	107.1	67.5	75.6	42.5	63.0
Run 10	565.9	597.3	572.3	502.7	460.0	393.7	357.5	272.7	419.5	342.8	633.2
Pond Area (m2)											
Field		2450.0	1800.0	1050.0	1050.0	600.0	600.0	125.0	125.0		125.0
Run 1	3100.0	5275.0	5825.0	5825.0	5825.0	5825.0	5825.0	5825.0	6325.0	6325.0	6975.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	2450.0	4225.0	4625.0	4625.0	4225.0	4225.0	4225.0	3825.0	4225.0	3825.0	4225.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	2450.0	4225.0	4225.0	4225.0	3825.0	3825.0	3100.0	3100.0	2450.0	2450.0	1800.0
Run 6	2450.0	2450.0	2450.0	1800.0	1800.0	1050.0	1050.0	600.0	600.0	125.0	125.0
Run 7	1800.0	1050.0	1050.0	1050.0	1050.0	600.0	600.0	125.0	125.0	125.0	0.0
Run 8	3825.0	4225.0	3825.0	3100.0	3100.0	2450.0	2450.0	1800.0	1800.0	1800.0	1800.0
Run 9	2450.0	2450.0	1800.0	1800.0	1800.0	1050.0	1050.0	600.0	1050.0	600.0	600.0
Run 10	2450.0	2450.0	2450.0	2450.0	2450.0	2450.0	2450.0	1800.0	2450.0	1800.0	3100.0
Pond Depth (m)											
Field		0.41	0.35	0.29	0.28	0.14	0.13	0.09	0.09		0.05
Run 1	0.50	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.10	1.10	1.20
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.40	0.70	0.80	0.80	0.70	0.70	0.70	0.60	0.70	0.60	0.70
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.40	0.70	0.70	0.70	0.60	0.60	0.50	0.50	0.40	0.40	0.30
Run 6	0.40	0.40	0.40	0.30	0.30	0.20	0.20	0.10	0.10	0.01	0.01
Run 7	0.30	0.20	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.00
Run 8	0.60	0.70	0.60	0.50	0.50	0.40	0.40	0.30	0.30	0.30	0.30
Run 9	0.40	0.40	0.30	0.30	0.30	0.20	0.20	0.10	0.20	0.10	0.10
Run 10	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.30	0.40	0.30	0.50

Table 7.6 Comparison of simulated pond volume, area and depth to field data for pond 197.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		999.7	737.6	523.0	433.0	340.0	201.3	172.0	162.3		22.0
Run 1	800.0	1255.0	1255.0	1255.0	1255.0	1255.0	1255.0	1255.0	1255.0	1255.0	1255.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	483.8	1255.0	1194.4	1088.2	1022.3	921.0	795.5	707.2	819.0	707.4	906.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	483.8	1255.0	972.4	867.4	714.3	593.3	375.7	212.4	150.6	37.4	0.0
Run 6	525.7	496.7	271.1	206.7	118.7	49.2	12.2	0.6	0.0	0.0	0.0
Run 7	201.3	199.2	63.1	41.6	18.7	2.5	0.0	0.0	0.0	0.0	0.0
Run 8	698.9	790.5	493.9	357.7	255.5	167.9	64.9	34.1	44.2	17.8	32.2
Run 9	516.2	542.5	256.4	165.2	99.0	41.9	14.7	2.0	9.6	2.8	21.2
Run 10	516.2	542.5	501.5	415.8	363.0	289.3	200.2	149.8	265.2	195.7	457.3
Pond Area (m2)											
Field		3700.0	3350.0	3000.0	3000.0	3000.0	1950.0	1950.0	1950.0		550.0
Run 1	3350.0	4475.0	4475.0	4475.0	4475.0	4475.0	4475.0	4475.0	4475.0	4475.0	4475.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	3000.0	4475.0	3700.0	3700.0	3700.0	3700.0	3350.0	3350.0	3350.0	3350.0	3700.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	3000.0	4475.0	3700.0	3350.0	3350.0	3350.0	3000.0	1950.0	1950.0	550.0	0.0
Run 6	3000.0	3000.0	3000.0	1950.0	1950.0	550.0	550.0	550.0	0.0	0.0	0.0
Run 7	1950.0	1950.0	1950.0	550.0	550.0	550.0	0.0	0.0	0.0	0.0	0.0
Run 8	3350.0	3350.0	3000.0	3000.0	3000.0	1950.0	1950.0	550.0	550.0	550.0	550.0
Run 9	3000.0	3000.0	3000.0	1950.0	1950.0	550.0	550.0	550.0	550.0	550.0	550.0
Run 10	3000.0	3000.0	3000.0	3000.0	3000.0	3000.0	1950.0	1950.0	3000.0	1950.0	3000.0
Pond Depth (m)											
Field		0.43	0.36	0.29	0.26	0.23	0.18	0.16	0.16		0.04
Run 1	0.30	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.20	0.50	0.40	0.40	0.40	0.40	0.30	0.30	0.30	0.30	0.40
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.20	0.50	0.40	0.30	0.30	0.30	0.20	0.10	0.10	0.01	
Run 6	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.00	0.00	0.00
Run 7	0.10	0.10	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 8	0.30	0.40	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.01
Run 9	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.01	0.01	0.01
Run 10	0.20	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.20	0.10	0.20

Table 7.7 Comparison of simulated pond volume, area and depth to field data for ponds 2 & 173.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field	226.8	445.0	78.5	4.8							
Run 1	327.5	327.5	327.5	327.5	327.5	327.5	327.5	327.5	327.5	327.5	327.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	209.9	375.0	326.9	242.7	190.7	110.5	56.4	37.1	82.6	56.4	137.1
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	209.9	375.0	169.7	89.2	43.0	14.0	0.8	0.0	0.0	0.0	0.0
Run 6	219.7	191.3	50.5	29.0	4.7	2.2	0.4	0.0	0.0	0.0	0.0
Run 7	54.0	48.5	11.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	327.7	341.6	51.5	13.0	2.1	0.8	0.2	0.0	0.0	0.0	0.0
Run 9	246.6	234.4	36.9	3.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Run 10	246.6	234.4	187.7	103.5	69.6	49.6	22.6	5.9	57.5	39.8	120.7
Pond Area (m2)											
Field	2425.0	3150.0	1550.0	475.0							
Run 1	5175.0	5175.0	5175.0	5175.0	5175.0	5175.0	5175.0	5175.0	5175.0	5175.0	5175.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	2450.0	5175.0	2450.0	2450.0	2450.0	2450.0	800.0	800.0	2450.0	800.0	2450.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	2450.0	5175.0	2450.0	2450.0	800.0	800.0	0.0	0.0	0.0	0.0	0.0
Run 6	2450.0	2450.0	800.0	475.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 7	800.0	800.0	800.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	2450.0	2450.0	800.0	800.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 9	2450.0	2450.0	800.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 10	2450.0	2450.0	2450.0	2450.0	800.0	800.0	800.0	800.0	800.0	800.0	2450.0
Pond Depth (m)											
Field	0.21	0.30	0.12	0.01							
Run 1	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.10	0.20	0.10	0.10	0.10	0.10	0.01	0.01	0.10	0.01	0.10
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.10	0.20	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 6	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 7	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 8	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 9	0.10	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 10	0.10	0.10	0.10	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.10

Table 7.8 Comparison of simulated pond volume, area and depth to field data for pond 6.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		429.5	333.1	278.5	161.5	116.0	70.5				358.1
Run 1	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	187.5	187.5	166.1	128.5	105.2	69.3	41.4	26.7	187.1	143.3	170.1
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	187.5	187.5	88.1	53.1	27.0	6.4	0.0	0.0	0.0	0.0	0.0
Run 6	181.1	168.3	71.2	46.2	20.1	0.0	0.0	0.0	0.0	0.0	0.0
Run 7	187.5	187.5	88.0	53.1	27.0	6.4	0.0	0.0	0.0	0.0	0.0
Run 8	187.5	187.5	73.0	37.1	17.8	0.0	0.0	0.0	0.0	0.0	10.4
Run 9	187.5	187.5	63.8	33.0	13.4	0.0	0.0	0.0	0.0	0.0	9.9
Run 10	187.5	187.5	168.0	130.5	107.2	71.4	41.8	26.9	187.1	143.3	170.1
Pond Area (m2)											
Field		2900.0	2275.0	2275.0	1300.0	1300.0	1300.0				2275.0
Run 1	2275.0	2275.0	2275.0	2275.0	2275.0	2275.0	2275.0	2275.0	2275.0	2275.0	2275.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	2275.0	2275.0	1300.0	1300.0	1300.0	1300.0	575.0	575.0	1300.0	1300.0	1300.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	2275.0	2275.0	1300.0	575.0	575.0	575.0	0.0	0.0	0.0	0.0	0.0
Run 6	1300.0	1300.0	1300.0	575.0	575.0	575.0	0.0	0.0	0.0	0.0	0.0
Run 7	2275.0	2275.0	1300.0	575.0	575.0	575.0	0.0	0.0	0.0	0.0	0.0
Run 8	2275.0	2275.0	1300.0	575.0	575.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 9	2275.0	2275.0	1300.0	575.0	575.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 10	2275.0	2275.0	1300.0	1300.0	1300.0	1300.0	575.0	575.0	1300.0	1300.0	1300.0
Pond Depth (m)											
Field		0.31	0.26	0.24	0.18	0.15	0.11				0.28
Run 1	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.20	0.20	0.10	0.10	0.10	0.10	0.01	0.01	0.10	0.10	0.10
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.20	0.20	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 6	0.10	0.10	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 7	0.20	0.20	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 8	0.20	0.20	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Run 9	0.20	0.20	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Run 10	0.20	0.20	0.10	0.10	0.10	0.10	0.01	0.01	0.10	0.10	0.10

Table 7.9 Comparison of simulated pond volume, area and depth to field data for pond 8.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		69.9	24.3								
Run 1	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	32.5	32.5	28.3	20.7	16.2	9.2	4.1	3.4	20.5	11.8	28.2
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	32.5	32.5	11.8	4.9	3.2	2.0	0.0	0.0	0.0	0.0	0.0
Run 6	31.3	28.9	8.6	4.4	2.8	1.6	0.0	0.0	0.0	0.0	0.0
Run 7	20.2	20.2	1.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	32.5	32.5	5.8	3.2	2.0	0.5	0.0	0.0	0.0	0.0	2.8
Run 9	32.5	31.6	5.6	3.2	2.0	0.4	0.0	0.0	0.0	0.0	2.8
Run 10	32.5	31.6	27.9	20.4	15.9	8.8	4.1	3.4	20.5	11.8	28.2
Pond Area (m2)											
Field		575.0	275.0								
Run 1	575.0	575.0	575.0	575.0	575.0	575.0	575.0	575.0	575.0	575.0	575.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	575.0	575.0	275.0	275.0	275.0	275.0	50.0	50.0	275.0	275.0	275.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	575.0	575.0	275.0	50.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0
Run 6	275.0	275.0	275.0	50.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0
Run 7	275.0	275.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	575.0	575.0	275.0	50.0	50.0	50.0	0.0	0.0	0.0	0.0	50.0
Run 9	575.0	275.0	275.0	50.0	50.0	50.0	0.0	0.0	0.0	0.0	50.0
Run 10	575.0	275.0	275.0	275.0	275.0	275.0	50.0	50.0	275.0	275.0	275.0
Pond Depth (m)											
Field		0.27	0.17								
Run 1	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.20	0.20	0.10	0.10	0.10	0.10	0.01	0.01	0.10	0.10	0.10
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.10	0.10	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 6	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 7	0.20	0.20	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 8	0.20	0.20	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01
Run 9	0.20	0.10	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01
Run 10	0.20	0.10	0.10	0.10	0.10	0.10	0.01	0.01	0.10	0.10	0.10

Table 7.10 Comparison of simulated pond volume, area and depth to field data for pond 194.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		751.0	751.0	373.0	163.8	92.9	62.5	12.5	12.5		62.5
Run 1	1177.5	1177.5	1177.5	1177.5	1177.5	1177.5	1177.5	1177.5	1177.5	1177.5	1177.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	941.6	1177.5	1069.5	880.0	764.8	584.4	411.6	320.9	603.6	430.4	917.6
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	941.6	1177.5	670.5	482.8	325.6	201.1	83.9	28.8	17.0	0.0	0.0
Run 6	974.6	956.7	453.2	323.8	186.2	117.6	46.3	7.2	0.0	0.0	0.0
Run 7	540.5	581.9	187.2	140.6	64.8	16.6	2.0	0.0	0.0	0.0	0.0
Run 8	1177.5	1175.6	566.8	378.8	256.1	139.5	79.4	38.6	76.6	35.0	89.2
Run 9	984.5	993.6	521.2	268.8	168.1	100.8	45.6	20.4	60.5	19.3	80.5
Run 10	984.5	993.6	900.1	756.9	634.1	562.6	335.7	238.8	573.6	427.0	908.3
Pond Area (m2)											
Field		5400.0	5400.0	5400.0	2025.0	2025.0	2025.0	625.0	625.0		2025.0
Run 1	8625.0	8625.0	8625.0	8625.0	8625.0	8625.0	8625.0	8625.0	8625.0	8625.0	8625.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	7150.0	8625.0	7150.0	7150.0	7150.0	2650.0	2650.0	2650.0	2650.0	2650.0	7150.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	7150.0	8625.0	7150.0	2650.0	2650.0	2650.0	675.0	500.0	500.0	0.0	0.0
Run 6	7150.0	7150.0	2650.0	2650.0	2650.0	2650.0	675.0	675.0	0.0	0.0	0.0
Run 7	2650.0	2650.0	2650.0	2650.0	675.0	675.0	675.0	0.0	0.0	0.0	0.0
Run 8	8625.0	7150.0	2650.0	2650.0	2650.0	2650.0	675.0	675.0	675.0	675.0	675.0
Run 9	7150.0	7150.0	2650.0	2650.0	2650.0	675.0	675.0	675.0	675.0	675.0	675.0
Run 10	7150.0	7150.0	7150.0	7150.0	7150.0	2650.0	2650.0	2650.0	2650.0	2650.0	7150.0
Pond Depth (m)											
Field		0.29	0.29	0.22	0.15	0.12	0.10	0.02	0.02		0.10
Run 1	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.30	0.40	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20	0.30
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.30	0.40	0.30	0.20	0.20	0.20	0.10	0.01	0.01	0.00	0.00
Run 6	0.30	0.30	0.20	0.20	0.20	0.20	0.10	0.10	0.00	0.00	0.00
Run 7	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.00	0.00	0.00	0.00
Run 8	0.40	0.30	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.10
Run 9	0.30	0.30	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.10	0.10
Run 10	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20	0.30

Table 7.11 Comparison of simulated pond volume, area and depth to field data for pond 189.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		1007.5	517.5	279.5	203.5	117.3	25.0				184.5
Run 1	1046.9	2722.3	3203.6	3203.6	3308.5	3343.4	3389.0	3416.9	3969.0	4004.0	4682.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	617.2	1956.5	2135.0	1920.8	1799.1	1611.3	1362.0	998.4	1329.6	1131.9	1307.9
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	617.2	1956.5	1700.9	1503.9	1201.7	992.9	614.5	383.0	285.7	150.8	39.1
Run 6	676.6	639.5	365.5	288.8	200.7	132.3	56.7	19.8	13.5	0.0	0.0
Run 7	255.5	261.1	198.2	143.9	86.4	48.9	12.9	0.9	0.0	0.0	0.0
Run 8	1221.4	1310.0	759.2	563.0	425.7	281.1	181.0	112.2	115.8	60.9	60.0
Run 9	748.6	745.9	362.2	251.7	186.2	112.9	58.5	23.9	26.5	13.6	55.0
Run 10	748.6	745.9	702.9	584.7	513.1	400.7	289.8	239.8	405.0	311.1	697.1
Pond Area (m2)											
Field		5800.0	4000.0	1900.0	1900.0	1025.0	1025.0				1900.0
Run 1	5800.0	7725.0	8650.0	8650.0	8650.0	8650.0	8650.0	8650.0	9975.0	9975.0	11525.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	4000.0	6875.0	7725.0	6875.0	6875.0	6875.0	6875.0	5800.0	6875.0	5800.0	6875.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	4000.0	6875.0	6875.0	6875.0	6875.0	5800.0	4000.0	4000.0	1900.0	1900.0	1025.0
Run 6	4000.0	4000.0	4000.0	1900.0	1900.0	1900.0	1025.0	250.0	250.0	0.0	0.0
Run 7	1900.0	1900.0	1900.0	1900.0	1025.0	1025.0	250.0	250.0	0.0	0.0	0.0
Run 8	5800.0	6875.0	5800.0	4000.0	4000.0	1900.0	1900.0	1025.0	1025.0	1025.0	1025.0
Run 9	5800.0	5800.0	4000.0	1900.0	1900.0	1025.0	1025.0	250.0	1025.0	250.0	1025.0
Run 10	5800.0	5800.0	4000.0	4000.0	4000.0	4000.0	1900.0	1900.0	4000.0	1900.0	4000.0
Pond Depth (m)											
Field		0.45	0.35	0.28	0.24	0.19	0.10				0.23
Run 1	0.40	0.60	0.70	0.70	0.70	0.70	0.70	0.70	0.80	0.80	0.90
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.30	0.50	0.60	0.50	0.50	0.50	0.50	0.40	0.50	0.40	0.50
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.30	0.50	0.50	0.50	0.50	0.40	0.30	0.30	0.20	0.20	0.10
Run 6	0.30	0.30	0.30	0.20	0.20	0.20	0.10	0.01	0.01	0.00	0.00
Run 7	0.20	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.00	0.00	0.00
Run 8	0.40	0.50	0.40	0.30	0.30	0.20	0.20	0.10	0.10	0.10	0.10
Run 9	0.40	0.40	0.30	0.20	0.20	0.10	0.10	0.01	0.10	0.01	0.10
Run 10	0.40	0.40	0.30	0.30	0.30	0.30	0.20	0.20	0.30	0.20	0.30

Table 7.12 Comparison of simulated pond volume, area and depth to field data for pond 5.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field	97.5	44.0	16.4								
Run 1	132.5	152.5	152.5	152.5	152.5	152.5	152.5	152.5	152.5	152.5	152.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	80.7	152.5	136.1	107.4	89.5	62.1	40.9	30.1	52.1	38.3	67.9
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	81.9	152.5	77.7	51.0	32.0	17.0	4.3	0.0	0.0	0.0	0.0
Run 6	86.2	76.5	25.0	13.0	6.5	3.4	0.0	0.0	0.0	0.0	0.0
Run 7	30.3	27.2	3.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	124.5	130.3	42.4	23.3	9.5	5.6	0.9	0.0	1.4	0.0	5.9
Run 9	104.0	100.1	30.6	11.5	7.1	3.3	0.1	0.0	0.7	0.0	5.6
Run 10	104.0	100.1	84.0	55.3	45.6	34.3	19.2	9.7	32.6	18.8	53.3
Pond Area (m2)											
Field	1000.0	425.0	425.0								
Run 1	1000.0	1750.0	1750.0	1750.0	1750.0	1750.0	1750.0	1750.0	1750.0	1750.0	1750.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	425.0	425.0	425.0	425.0	1000.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	1000.0	1750.0	1000.0	425.0	425.0	425.0	100.0	0.0	0.0	0.0	0.0
Run 6	1000.0	1000.0	425.0	425.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
Run 7	425.0	425.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	1000.0	1000.0	425.0	425.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
Run 9	1000.0	1000.0	425.0	425.0	100.0	100.0	100.0	0.0	100.0	0.0	100.0
Run 10	1000.0	1000.0	1000.0	1000.0	425.0	425.0	425.0	100.0	425.0	425.0	1000.0
Pond Depth (m)											
Field	0.25	0.18	0.12								
Run 1	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.20	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10	0.20
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.20	0.30	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00
Run 6	0.20	0.20	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 7	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 8	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.00	0.01	0.00	0.01
Run 9	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.00	0.01	0.00	0.01
Run 10	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.01	0.10	0.10	0.20

Table 7.13 Comparison of simulated pond volume, area and depth to field data for pond 182.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field			225.9	121.5	71.5	34.5	9.7				
Run 1	762.5	762.5	762.5	762.5	762.5	762.5	762.5	762.5	762.5	762.5	762.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	762.5	762.5	723.3	654.4	612.3	546.7	469.1	416.7	606.1	526.1	719.6
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	762.5	762.5	580.8	513.2	422.9	349.8	224.9	155.0	78.4	32.1	14.7
Run 6	750.9	727.8	547.7	485.0	494.7	321.6	202.5	155.0	155.0	15.0	15.0
Run 7	350.1	364.0	227.7	180.5	155.0	75.3	22.6	0.0	0.0	0.0	0.0
Run 8	762.5	760.9	540.9	445.4	377.9	295.3	209.8	147.1	142.1	94.9	72.4
Run 9	761.9	761.0	538.5	443.6	375.3	293.3	207.9	145.7	140.9	93.8	71.1
Run 10	761.9	761.0	730.4	659.8	618.8	551.7	472.1	418.4	606.0	531.7	727.1
Pond Area (m2)											
Field			1625.0	1000.0	1000.0	550.0	550.0				
Run 1	2700.0	2700.0	2700.0	2700.0	2700.0	2700.0	2700.0	2700.0	2700.0	2700.0	2700.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	2700.0	2700.0	2425.0	2425.0	2425.0	2425.0	2025.0	2025.0	2425.0	2425.0	2425.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	2700.0	2700.0	2425.0	2025.0	2025.0	2025.0	1500.0	1500.0	925.0	150.0	150.0
Run 6	2425.0	2425.0	2425.0	2025.0	2025.0	2025.0	1500.0	1500.0	1500.0	150.0	150.0
Run 7	2025.0	2025.0	1500.0	1500.0	1500.0	925.0	150.0	0.0	0.0	0.0	0.0
Run 8	2700.0	2425.0	2425.0	2025.0	2025.0	1500.0	1500.0	925.0	925.0	925.0	925.0
Run 9	2700.0	2425.0	2425.0	2025.0	2025.0	1500.0	1500.0	925.0	925.0	925.0	925.0
Run 10	2700.0	2425.0	2425.0	2425.0	2425.0	2425.0	2025.0	2025.0	2425.0	2425.0	2425.0
Pond Depth (m)											
Field			0.34	0.26	0.21	0.15	0.10				
Run 1	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.60	0.60	0.50	0.50	0.50	0.50	0.40	0.40	0.50	0.50	0.50
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.60	0.60	0.50	0.40	0.40	0.40	0.30	0.30	0.20	0.10	0.10
Run 6	0.50	0.50	0.50	0.40	0.40	0.40	0.30	0.30	0.30	0.10	0.10
Run 7	0.40	0.40	0.30	0.30	0.30	0.20	0.10	0.00	0.00	0.00	0.00
Run 8	0.60	0.50	0.50	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.20
Run 9	0.60	0.50	0.50	0.40	0.40	0.30	0.30	0.20	0.20	0.20	0.20
Run 10	0.60	0.50	0.50	0.50	0.50	0.50	0.40	0.40	0.50	0.50	0.50

Table 7.14 Comparison of simulated pond volume, area and depth to field data for pond 7.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		83.5	58.6	30.8	18.4						
Run 1	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	37.5	37.5	34.1	28.0	24.5	18.8	13.4	11.3	24.4	17.5	33.6
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	37.5	37.5	20.6	14.7	10.8	7.7	3.2	0.0	0.0	0.0	0.0
Run 6	36.6	34.6	18.0	13.8	9.9	6.8	2.8	0.0	0.0	0.0	0.0
Run 7	21.4	20.0	8.5	6.1	3.6	2.4	0.0	0.0	0.0	0.0	0.0
Run 8	37.5	37.5	16.2	11.3	8.4	4.7	2.6	1.0	0.0	0.0	0.5
Run 9	37.5	36.4	15.1	10.9	8.0	4.7	2.6	1.0	1.7	0.0	0.5
Run 10	37.5	36.4	33.2	27.1	23.6	17.9	13.0	10.9	24.0	17.0	33.6
Pond Area (m2)											
Field		450.0	325.0	225.0	225.0						
Run 1	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	325.0	325.0	225.0	225.0	225.0	225.0	100.0	100.0	225.0	225.0	225.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	325.0	325.0	225.0	100.0	100.0	100.0	50.0	0.0	0.0	0.0	0.0
Run 6	225.0	225.0	225.0	100.0	100.0	100.0	50.0	0.0	0.0	0.0	0.0
Run 7	225.0	225.0	100.0	100.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0
Run 8	325.0	325.0	225.0	100.0	100.0	50.0	50.0	50.0	0.0	0.0	50.0
Run 9	325.0	225.0	225.0	100.0	100.0	50.0	50.0	50.0	50.0	0.0	50.0
Run 10	325.0	225.0	225.0	225.0	225.0	225.0	225.0	100.0	225.0	225.0	225.0
Pond depth (m)											
Field		0.43	0.37	0.27	0.22						
Run 1	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.30	0.30	0.20	0.20	0.20	0.20	0.10	0.10	0.20	0.20	0.20
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.30	0.30	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00
Run 6	0.20	0.20	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00
Run 7	0.20	0.20	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Run 8	0.30	0.30	0.20	0.10	0.10	0.01	0.01	0.01	0.00	0.00	0.01
Run 9	0.30	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.01	0.00	0.01
Run 10	0.30	0.20	0.20	0.20	0.20	0.20	0.20	0.10	0.20	0.20	0.20

Table 7.15 Comparison of simulated pond volume, area and depth to field data for pond 9-West.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		208.5	75.0								
Run 1	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	135.0	135.0	122.3	100.0	86.8	65.5	46.8	37.8	100.9	75.0	122.6
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	135.0	135.0	74.3	53.4	37.4	24.8	9.1	0.0	0.0	0.0	0.0
Run 6	131.4	124.0	65.1	49.1	33.0	20.4	6.8	0.0	0.0	0.0	0.0
Run 7	65.0	59.5	74.3	53.4	37.4	24.8	9.1	0.0	0.0	0.0	0.0
Run 8	135.0	135.0	71.6	46.2	34.4	18.9	9.7	3.3	7.3	1.5	8.8
Run 9	135.0	134.7	92.7	56.9	44.0	28.5	13.2	6.8	10.8	3.0	10.5
Run 10	135.0	134.7	122.3	100.0	86.8	65.6	46.8	37.8	101.3	75.5	122.6
Pond Area (m2)											
Field		1225.0	800.0								
Run 1	1225.0	1225.0	1225.0	1225.0	1225.0	1225.0	1225.0	1225.0	1225.0	1225.0	1225.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	1225.0	1225.0	800.0	800.0	800.0	800.0	375.0	375.0	800.0	800.0	800.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	1225.0	1225.0	800.0	375.0	375.0	375.0	175.0	0.0	0.0	0.0	0.0
Run 6	800.0	800.0	800.0	375.0	375.0	375.0	175.0	0.0	0.0	0.0	0.0
Run 7	800.0	800.0	800.0	375.0	375.0	375.0	175.0	0.0	0.0	0.0	0.0
Run 8	1225.0	1225.0	800.0	375.0	375.0	375.0	175.0	175.0	175.0	175.0	175.0
Run 9	1225.0	800.0	800.0	800.0	375.0	375.0	175.0	175.0	175.0	175.0	175.0
Run 10	1225.0	800.0	800.0	800.0	800.0	800.0	375.0	375.0	800.0	800.0	800.0
Pond Depth (m)											
Field		0.36	0.23								
Run 1	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.30	0.30	0.20	0.20	0.20	0.20	0.10	0.10	0.20	0.20	0.20
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.30	0.30	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00
Run 6	0.20	0.20	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00
Run 7	0.20	0.20	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00
Run 8	0.30	0.30	0.20	0.10	0.10	0.10	0.01	0.01	0.01	0.01	0.01
Run 9	0.30	0.20	0.20	0.20	0.10	0.10	0.01	0.01	0.01	0.01	0.01
Run 10	0.30	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.20	0.20	0.20

Table 7.16 Comparison of simulated pond volume, area and depth to field data for pond 9-East.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field		639.4	523.0	377.8	316.5	157.3	34.8				157.3
Run 1	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	40.0	40.0	35.3	27.0	24.2	16.7	7.6	5.4	40.0	30.6	40.0
Run 4	0.0	0.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Run 5	40.0	40.0	10.8	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 6	39.9	36.7	11.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 7	40.0	38.5	10.8	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	40.0	40.0	8.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 9	40.0	39.6	16.5	3.5	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Run 10	40.0	39.6	35.4	27.1	24.3	16.8	7.6	5.2	40.0	30.6	40.0
Pond Area (m2)											
Field		3325.0	3325.0	2450.0	2450.0	2450.0	1225.0				2450.0
Run 1	1125.0	1125.0	1125.0	1125.0	1125.0	1125.0	1125.0	1125.0	1125.0	1125.0	1125.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	1125.0	1125.0	325.0	325.0	325.0	325.0	325.0	325.0	1125.0	325.0	1125.0
Run 4	0.0	0.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0
Run 5	1125.0	1125.0	325.0	325.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 6	325.0	325.0	325.0	325.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 7	1125.0	325.0	325.0	325.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 8	1125.0	1125.0	325.0	325.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 9	1125.0	325.0	325.0	325.0	325.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 10	1125.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	325.0	1125.0
Pond Depth (m)											
Field		0.38	0.34	0.30	0.27	0.21	0.11				0.21
Run 1	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.10	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.10	0.01	0.10
Run 4	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Run 5	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 6	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 7	0.10	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 8	0.10	0.10	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 9	0.10	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Run 10	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.10

Table 7.17 Comparison of simulated pond volume, area and depth to field data for pond 3.

Model Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
Pond Volume (m3)											
Field					28.8						
Run 1	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	10.0	10.0	9.2	9.0	9.6	8.9	7.7	7.1	9.5	8.6	9.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	10.0	10.0	5.1	5.0	2.5	0.7	0.0	0.0	0.0	0.0	0.0
Run 6	10.0	10.0	5.1	5.0	2.5	0.7	0.0	0.0	0.0	0.0	0.0
Run 7	9.9	9.7	7.6	6.6	3.2	0.6	0.0	0.0	0.0	0.0	0.0
Run 8	10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 9	10.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 10	10.0	9.9	8.8	7.8	8.0	7.3	6.1	5.4	9.5	9.2	9.0
Pond Area (m2)											
Field					750.0						
Run 1	475.0	475.0	475.0	475.0	475.0	475.0	475.0	475.0	475.0	475.0	475.0
Run 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 3	475.0	475.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
Run 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 5	475.0	475.0	75.0	75.0	75.0	25.0	0.0	0.0	0.0	0.0	0.0
Run 6	475.0	475.0	75.0	75.0	75.0	25.0	0.0	0.0	0.0	0.0	0.0
Run 7	75.0	75.0	75.0	75.0	75.0	25.0	0.0	0.0	0.0	0.0	0.0
Run 8	475.0	475.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 9	475.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Run 10	475.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
Pond Depth (m)											
Field					0.22						
Run 1	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Run 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 3	0.20	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Run 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 5	0.20	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00	0.00
Run 6	0.20	0.20	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00	0.00
Run 7	0.10	0.10	0.10	0.10	0.10	0.01	0.00	0.00	0.00	0.00	0.00
Run 8	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 9	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Run 10	0.20	0.20	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Table 7.18 Comparison of percent agreement between simulated pond volume and field data for all ponds and dates for the most correct simulaton runs.

Pond No.	Run No.	Mar-31	Apr-4	Apr-12	Apr-19	Apr-26	May-3	May-10	May-17	May-24	Jun-1	Jun-15
185_E	6	na	103	97	73	78	95	95	58	75	na	53
	9	na	103	97	73	78	95	95	58	75	na	53
185-W	6	na	94	88	69	70	78	79	50	56	na	41
	9	na	98	88	69	70	78	79	50	56	na	41
184	6	na	87	79	104	105	109	92	91	65	na	0
	9	na	87	79	104	105	109	92	91	65	na	0
155	6	105	130	110	133	155	na	na	na	na	na	0
	9	99	135	77	109	131	na	na	na	na	na	6
157	6	na	149	138	180	146	410	315	446	289	na	27
	9	na	162	96	167	145	442	351	597	669	na	1000
197	6	na	50	37	40	27	14	6	0	0	na	0
	9	na	54	35	32	23	12	7	1	6	na	96
2&173	6	97	43	64	604	na	na	na	na	na	na	na
	9	109	53	47	75	na	na	na	na	na	na	na
6	6	na	39	21	17	12	0	0	na	na	na	0
	9	na	44	19	12	8	0	0	na	na	na	3
	10	na	44	50	47	66	62	59	na	na	na	48
8	6	na	41	35	na	na	na	na	na	na	na	na
	8	na	46	24	na	na	na	na	na	na	na	na
	9	na	45	23	na	na	na	na	na	na	na	na
194	6	na	127	60	87	114	127	74	58	0	na	0
	9	na	132	69	72	103	109	73	163	484	na	129
189	6	na	63	71	103	99	113	227	na	na	na	0
	9	na	74	71	103	99	113	227	na	na	na	0
5	6	88	174	152	na	na	na	na	na	na	na	na
	9	107	228	187	na	na	na	na	na	na	na	na
182	6	na	na	242	399	692	932	2088	na	na	na	na
	7	na	na	101	149	217	218	233	na	na	na	na
	9	na	na	238	365	525	850	2143	na	na	na	na
7	5	na	45	35	48	59	na	na	na	na	na	na
	6	na	41	31	45	54	na	na	na	na	na	na
	9	na	44	26	35	43	na	na	na	na	na	na
9-W	8	na	65	95	na	na	na	na	na	na	na	na
	9	na	65	124	na	na	na	na	na	na	na	na
9-E	9	na	6	3	1	0	0	0	na	na	na	0
3	6	na	na	na	na	9	na	na	na	na	na	na
	9	na	na	na	na	0	na	na	na	na	na	na

Note: The simulated pond volume is expressed as a percentage of the measured pond volume in the above table. Values in excess of 100 indicate that the simulation run over-estimated the volume of the pond while values less than 100 indicate an under-estimate.

Table 8.1 Summary analysis of simulation success by pond type and volume.

Pond Number	Relative Success of Simulation	Max Pond Volume (m3)	Completely Defined by DEM?	Number of Subsidiary Ponds	Critical Factors Affecting Success of Simulation
185-E	Good	1032	Yes	4 & 2	Good model performance related to correct estimate of snowdepth. Errors in estimating snowdepth probably averaged out over this large watershed.
185-W	Good	1560	Yes	5 & 2	Same as 185-E. Snowdepth correctly estimated.
184	Good	545	Yes	2	Pond volume and depth correctly estimated. Since the pond overspilled it achieved the correct inital maximum volume for any assigned snowdepth sufficient to fill it to its maximum volume.
155	Moderate	970	Yes	2 & 1	Good estimates of initial volume. Pond decay didn't match survey data completely. This may be due to oversight in field survey.
157	Poor	855	Yes	4 & 2	Overestimated initial pond volume. Error may be due to over-estimate of snow depth or to more rapid infiltration than simulated.
197	Poor	997	Yes	4 & 1	Initial pond volume under-estimated. Pond may have contained residual water at start of spring runoff or snow depth may have been under-estimated.
2&173	Poor	445	No	4 & 1	DEM analysis under-estimated depth and volume of ponds. Incompletely defined catchment and under-estimate of snow depth led to under-estimate of runoff.
6	Moderate	429	Yes	1	Maximum pond volume under-estimated due to errors in DEM or perhaps snow damming.
8	Poor	70	Yes	1	Maximum pond volume under-estimated due to errors in DEM or perhaps snow damming.
194	Moderate	994	No	14	Simulated volumes quite close to field survey despite incomplete definition of watersheds & ponds by DEM.
189	Moderate	1007	No	9 & 4	Initial pond volume under-estimated due to incomplete definition of watersheds by DEM.
5	Poor	132	No	1	Watershed and pond incompletely defined by DEM.
182	Poor	226	No	1	Watershed and pond incompletely defined by DEM.
7	Poor	38	No	1	Watershed and pond incompletely defined by DEM.
9-W	Poor	135	No	2 & 1	Watershed and pond incompletely defined by DEM.
9-E	Poor	40	No	6	Watershed and pond incompletely defined by DEM.
3	Poor	10	No	1	Watershed and pond incompletely defined by DEM.

Table suggested and initially produced by Burrough, 1994, personal communication.

APPENDICES

APPENDIX 1

PROGRAM LISTING FOR PROGRAM PONDMAP

```
*************************************************************
* PROGRAM PONDMAP
*************************************************************
* This program is used to read field survey data detailing the location
* and elevation of all major ponds and to use this data to determine the
* extent and depth of ponding for each grid element in the DEM data set
* that would have been flooded by the measured ponding. All grid cells
* located in the watershed associated with a given measured pond are
* flooded to the measured elevation of ponding. The volume and area of
* each pond are computed and recorded in a table of pond statistics
* (PONDSTAT). The depth of ponding is computed for every grid cell and,
* after all ponds have been processed for a given survey date, the depth
* of ponding for every grid cell is recorded in both a dBase III+ data
* base table and a text file suitable for making raster maps.
*************************************************************
SET TALK OFF
SET ECHO OFF

* Declare and initialize all variables so that they are common to all
* procedures

C        = 0
C2       = 0
CENTREC  = 0
CHEKDATE = 0
CHEKNUM  = 0
COL1     = 0
COL2     = 0
ELEVPOND = 0
FIRSTELEV= 0.0
GRIDFILE = "LUNTYGRD"
LASTDATE = 0
```

```
ELEVPIT  = 0
MAPFILE  = "     "
MAPTXT   = "     "
MAXDEP   = 0.0
PONDIFF  = 0
PONDEPTH = 0
PONDSURV = "POND89S"
PONDVOL  = 0
PONDAREA = 0
SHEDNUM  = 0
R        = 0
SELECT A
USE &GRIDFILE ALIAS GRIDAT
SET INDEX TO BOTTOMUP
* DO ZEROGRID

SELECT C
USE PONDSTAT ALIAS PONDOUT
SET SAFETY OFF
ZAP
SET SAFETY ON

SELECT B
USE &PONDSURV ALIAS PONDIN
GO TOP
LASTDATE  = CHEKDAY

DO TEMPLATE

DO WHILE .NOT. EOF()  && LOOP THROUGH THE POND SURVEY DATA
FILE (POND89S)

  CHEKDATE = CHEKDAY
  CHEKNUM  = PONDNO
  SHEDNUM  = SHEDNO
  PONDIFF  = ELEVDIFF
  CENTREC  = PITREC
```

```
ELEVPIT  = PITELEV
ELEVPOND = CORRELEV

IF LASTDATE <> CHEKDATE
 DO MAKEMAPS
 LASTDATE = CHEKDATE
ENDIF

@ R+1,  COL1   SAY CHEKNUM PICTURE "XXXXXXXX"
@ R+2,  COL1   SAY SHEDNUM PICTURE "###"
@ R+3,  COL1   SAY CENTREC PICTURE "######"

@ R+5,  COL1   SAY ELEVPIT  PICTURE "###.###"
@ R+6,  COL1   SAY ELEVPOND PICTURE "###.###"

@ R+8,  COL1   SAY PONDIFF  PICTURE "##.###"
@ R+9,  COL1   SAY CHEKDATE PICTURE "######"
@ R+10, COL1   SAY LASTDATE PICTURE "######"

SELECT GRIDAT
GOTO CENTREC
FIRSTELEV = ELEV
PONDVOL   = 0.0
PONDAREA  = 0.0
FLOODELEV = ELEVPOND
@ 19, 3  SAY "Processing grid file to climb up from pit centre"

DO WHILE ELEV <= FLOODELEV .AND. SHEDNOW = SHEDNUM
* THIS LOOP IS USED TO CLIMB UP GRID FILE FROM PIT CENTRE
 PONDEPTH  = FLOODELEV - ELEV
 PONDVOL   = PONDVOL + PONDEPTH
 PONDAREA  = PONDAREA + 1
 REPLACE PONDELEV WITH FLOODELEV
 REPLACE PONDEP WITH PONDEPTH
 @ R+1,  COL2  SAY SHEDNOW  PICTURE "###"
 @ R+2,  COL2  SAY SHEDNO   PICTURE "###"
 @ R+3,  COL2  SAY RECNO()  PICTURE "#####"
```

```
  @ R+4, COL2 SAY ROW     PICTURE "###"
  @ R+5, COL2 SAY COL     PICTURE "###"
  @ R+6, COL2 SAY ELEV    PICTURE "###.#"
  @ R+7, COL2 SAY UPSLOPE PICTURE "#####"
  @ R+8, COL2 SAY PONDEPTH PICTURE "##.###"
  @ R+9, COL2 SAY PONDVOL PICTURE "####.#"
  @ R+10, COL2 SAY PONDAREA PICTURE "####"
  SKIP
 ENDDO

  SELECT PONDOUT  && RECORD COMPUTED POND STATISTICS TO
OUTPUT FILE
 @ 19, 3 SAY "Outputting pond statistics to file PONDSTAT.dbf    "
 APPEND BLANK
 REPLACE CHEKDAY WITH CHEKDATE
 REPLACE PONDNO WITH CHEKNUM
 REPLACE SHEDNO WITH SHEDNUM
 REPLACE PVOL WITH PONDVOL
 REPLACE PAREA WITH PONDAREA
 REPLACE PITELEV WITH FIRSTELEV
 REPLACE PONDELEV WITH FLOODELEV
 REPLACE MAXDEPTH WITH PONDIFF
 @ 19, 3 SAY "                              "

  SELECT PONDIN  && RETURN TO INPUT FILE OF POND STATISTICS
(POND89S)
 SKIP
ENDDO
****************************************************************
****************************************************************
PROCEDURE TEMPLATE
****************************************************************
* Procedure used to write a template to the screen. This form is used to
* provide updated information on the data being used to compute pond
* location and depth and of the progress being made in the computations
****************************************************************
clear
```

```
set color to W/B, N/R,

frame =     CHR(201) + CHR(205) + CHR(187) + CHR(186) + ;
            CHR(188) + CHR(205) + CHR(200) + CHR(186) + ;
            CHR(32)

STORE  1 to TOP
STORE  0 to LEFT
STORE 20 to BOTTOM
STORE 79 to RIGHT

@ TOP,LEFT,BOTTOM,RIGHT BOX FRAME
@ 2,8 SAY "PONDMAP ROUTINE: Used to create maps of pond depth and extent"
@ 3,8 SAY "              based on measured elevation of actual ponds"

@ 21, 0 CLEAR TO  22, 79

R    = 5
C    = 3
C2   = 45
COL1 = 33
COL2 = 69

@ R,    C  SAY "INPUT DATA"

@ R+1,  C  SAY "Field check pond number   : "
@ R+2,  C  SAY "Watershed shed number     : "
@ R+3,  C  SAY "Pond centre record number : "

@ R+5,  C  SAY "Pond centre elevation     : "
@ R+6,  C  SAY "Measured pond elevation   : "

@ R+8,  C  SAY "Maximum depth of ponding  : "
@ R+9,  C  SAY "Date of field checking    : "
@ R+10, C  SAY "Last date checked         : "

@ R,    C2 SAY "CURRENT DATA VALUES"
```

```
@ R+1,  C2  SAY "Shed Now          : "
@ R+2,  C2  SAY "Shed Number       : "
@ R+3,  C2  SAY "Record Number     : "
@ R+4,  C2  SAY "Row               : "
@ R+5,  C2  SAY "Col               : "
@ R+6,  C2  SAY "Elevation         : "
@ R+7,  C2  SAY "Upslope area      : "
@ R+8,  C2  SAY "Depth of ponding  : "
@ R+9,  C2  SAY "Current pond volume : "
@ R+10, C2  SAY "Current pond area  : "

@ R+12, C   SAY "Present activity is : "
***************************************************************
***************************************************************
PROCEDURE MAKEMAPS
***************************************************************
* This procedure copies to a dBase file named MAP+DATE the entire grid
* with the depth of ponding indicated for all cells affected by ponding
* at the given date on which the field checking took place. It also
* produces a simple ascii text file of depth of ponding of all cells in
* sequential order from top left to bottom right cell. This is suitable
* for direct inputinto IDRISI for producing grey scale image maps. It can
* also be easily reformatted into an M x N matrix for display and mapping
* in PC-Geostat or any raster display capability
***************************************************************
MAPFILE = "MP"+LTRIM(TRIM(LASTDATE))
SELECT GRIDAT
@ 19, 3  SAY "Copying grid data ponding info to "+ MAPFILE
SET INDEX TO
GO TOP
COPY TO &MAPFILE FIELDS ROW,COL,ELEV,SHEDNO,SHEDNOW,PONDEP
@ 19, 3  SAY "                              "
GO TOP
MAPIMG = MAPFILE+".IMG"
@ 19, 3  SAY "Copying ponding data to text file "+ MAPIMG
SET ALTERNATE TO &MAPIMG
SET ALTERNATE ON
```

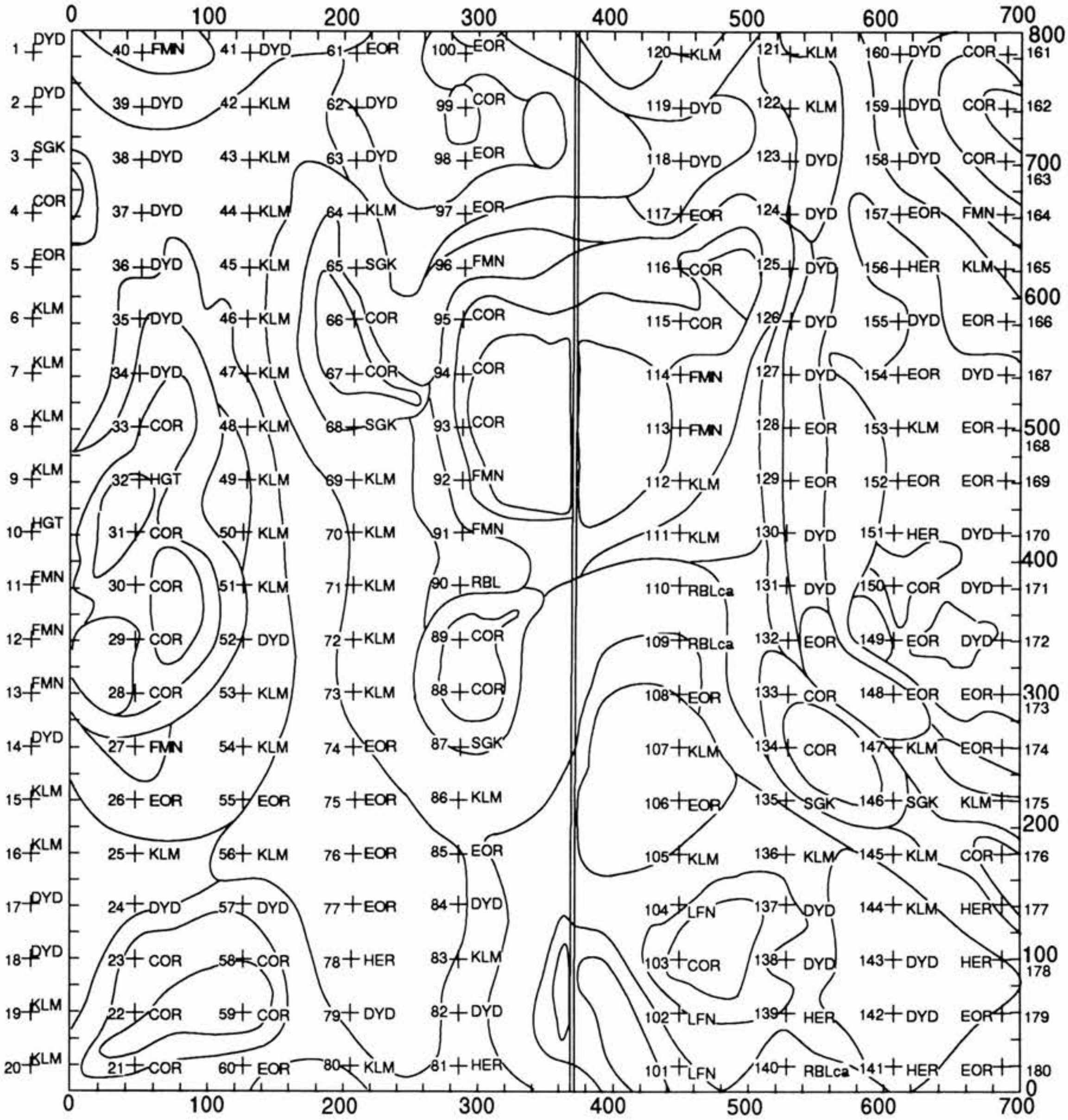
```
LIST OFF FIELDS PONDEP
* REPORT FORM PONDMAP TO &MAPFILE PLAIN NOEJECT
* SET ALTERNATE OFF
CLOSE ALTERNATE
DO TEMPLATE
DO ZEROGRID
****************************************************************
****************************************************************
PROCEDURE ZEROGRID
****************************************************************
* This procedure resets the fields PONDEP to zero (0) and PONDELEV to ELEV
* in the grid file LUNTYGRD. The values are set to defaults at the start of
* the program and reset at the start of any new date of pond survey. This
* is necessary to ensure that the maps of pond depth or pond elevation for
* any given date do not retain any left over data from the previous date.
****************************************************************
@ 19, 3  SAY "                              "
GO TOP
@ 19, 3  SAY "Resetting fields PONDEP and PONDELEV to zero! "
DO WHILE .NOT. EOF()
 IF PONDEP <> 0.0
  REPLACE PONDEP WITH 0.0
 ENDIF
 IF PONDELEV <> ELEV
  REPLACE PONDELEV WITH ELEV
 ENDIF
 SKIP
ENDDO
@ 19, 3  SAY "                              "
SET INDEX TO BOTTOMUP
****************************************************************
```

APPENDIX 2

GRID SOIL SURVEY DATA FOR THE LUNTY SITE

A2.1 Introduction

This appendix contains all data collected for the detailed grid soil survey of the Lunty site. The systematic grid soil survey was undertaken to determine if the soils at the Lunty site were distributed according to some recogniseable spatial pattern. The locations of all grid observation sites and the code for the Soil Series recognised at each site are indicated on Figure A2.1. The observations and classifications made at each grid site are listed in Table A2.1 The grid survey data confirmed the existance of a regular, consistent relationship between soils and topographical position. This conceptual soil-landscape model was used to develop a choropleth soil map for the Lunty site. The boundaries of the choropleth map entities are included on figure A2.1 to indicate how the individual grid observation sites were grouped into areal units.



Scale 1:5,500

Figure A2.1 Soil Series classification of grid survey observation points at the Lunty site.

Table A2.1 Grid soil survey site observation data

							Type of Slope			A-horizon desc			B-horizon Description					C-horizon Desc			Profile
Site No.	Row (x)	Col (y)	Ser Code	Map Unit	Soil SubG	Type of PM	%	Pos	Shape	Type	Dep	Text	Th	Type	Dep	Text	Structure	Type	Dep	Text	Drainage Class
1	1	1	DYD	DYD1/3	BL.SO	CL Till	1	Up	Cv	Ap	25	L	5	Bnt	25	CL-C	St Med Pr	Csk	75	CL	Mod Well
2	2	1	DYD	DYD1/2	BL.SO	CL Till	2	Cr	Cv	Ap	20	L	5	Bnt	25	CL-C	St Med Pr	Csk	75	CL	Well
3	3	1	SGK	COR1/3	E.BL	CL Till	3	Low	Ca	Ap	17	L	5	Bt	22	CL	Mod Med Pr	Csk	75	CL	Mod Well
4	4	1	COR	COR1/2	HU.LG	CL Till	1	Dep	Ca	Ap	18	L	10	Btg	28	CL-C	Mod Med Pr	BCg	120	CL	Imp-Poor
5	5	1	EOR	KLM1/2	O.BL	CL Till	2	Up	Cv	Ap	13	L	0	Bm	13	CL	Wk Med Pr	Csk	35	CL	Mod Well
6	6	1	KLM	KLM1/2	BL.SS	CL Till	2	Mid	Cv	Ap	15	L-CL	0	Bnt	15	C	St Fn SAB	Ccasa	40	CL	Mod Well
7	7	1	KLM	KLM1/2	BL.SS	CL Till	3	Mid	Cv	Ap	15	L-CL	0	Bnt	15	C-CL	St Fn SAB	Ccasa	33	CL	Mod Well
8	8	1	KLM	KLM1/2	BL.SS	CL Till	2	Low	Ca	Ap	15	L-CL	0	Bnt	15	C-CL	St Fn SAB	Ccasa	38	CL	Mod Well
9	9	1	KLM	KLM1/2	BL.SS	CL Till	1	Toe	Ca	Ap	18	L-CL	10	Bntg	28	C-CL	St Fn SAB	Ccasag	48	CL	Imp
10	10	1	HGT	FMN1/3	O.HG	C Till	1	Toe	Ca	Ap	15	C-CL	0	Btgnj	15	C-CL	Mod Fn SAB	Ccasag	37	CL-C	Imp-Poor
11	11	1	FMN	FMN1/3	SZ.LG	C Till	1	Dep	Ca	Ap	15	CL-C	0	Btgnj	15	C	St Fn SAB	Ccasag	28	C-CL	Poor
12	12	1	FMN	FMN1/3	SZ.LG	C Lac	1	Dep	Ca	Ah	10	CL	0	Btgnj	10	C	Massive	Ccasag	48	C	Poor
13	13	1	FMN	FMN1/3	SZ.LG	C Lac	1	Toe	Ca	Ah	10	L	2	Btgnj	12	C	Massive	Ccasag	30	C	Poor
14	14	1	DYD	KLM1/3	BL.SO	CL Till	5	Up	Ca	Ap	15	L	1	Btnj	16	CL	Mod Med Pr	Ck	60	CL	Well
15	15	1	KLM	KLM1/3	BL.SS	CL Till	2	Cr	Cv	Ap	15	L	5	Bnt	20	C-CL	St Med Pr	Csk	60	CL	Mod Well
16	16	1	KLM	KLM1/2	BL.SS	CL Till	2	Cr	Cv	Ap	15	L	5	Bnt	20	C-CL	St Med Col	Csk	55	CL	Mod Well
17	17	1	DYD	KLM1/2	BL.SO	CL Till	3	Low	Cv	Ap	20	L	13	Btnj	33	C-CL	St Med Col	Csk	85	CL	Well
18	18	1	DYD	KLM1/2	BL.SO	CL Till	2	Mid	Cv	Ap	20	L	10	Btnj	30	CL	Mod Med Col	Csk	75	CL	Well
19	19	1	KLM	KLM1/3	BL.SS	CL Till	3	Low	Cv	Ap	15	L	9	Bnt	24	CL	Mod Med Pr	Csk	70	CL	Mod Well
20	20	1	KLM	KLM1/3	BL.SS	CL Till	3	Low	Cv	Ap	20	L	3	Bnt	23	C	St Med Pr	Csk	70	CL	Mod Well
21	20	3	COR	COR1/3	HU.LG	CL Till	3	Dep	Ca	Ap	18	L	16	Btg	34	C	Massive	BCg	120	CL	Poor-Imp
22	19	3	COR	COR1/1	HU.LG	C Till	2	Toe	Cv	Ap	17	L	10	Btg	27	C	Massive	Ckg	75	CL	Poor-Imp
23	18	3	COR	COR1/3	HU.LG	C Till	3	Low	Cv	Ap	20	L	10	Btg	30	C	St Fn SAB	Ckg	87	CL	Poor
24	17	3	DYD	KLM1/2	BL.SO	CL Till	3	Up	Cv	Ap	20	L	10	Bt	30	CL-C	Mod Med Pr	Ck	65	CL	Well
25	16	3	KLM	KLM1/2	BL.SS	CL Till	4	Up	Cv	Ap	15	L	4	Bnt	19	C	St Fn Blk	Ccasa	43	CL	Imp
26	15	3	EOR	KLM1/3	O.BL	L SlpWs	3	Low	Cv	Ap	30	L	0	Bm	40	CL-L	Mod Med SAB	Csk	110	CL	Well
27	14	3	FMN	FMN1/3	SZ.LG	CL Till	2	Toe	Ca	Ap	23	L	10	Bnt	33	C-CL	St Med Pr	Csakg	120	CL	Mod Well
28	13	3	COR	COR1/3	HU.LG	Cl Till	1	Dep	Ca	Ah	14	L	12	Btg	26	C	Massive	BCg	120	CL	Poor-Imp
29	12	3	COR	COR1/1	HU.LG	CL Till	1	Dep	Ca	Ah	20	L	18	Btg	38	C	Massive	BCg	120	CL	Poor-Imp
30	11	3	COR	COR1/3	HU.LG	CL Till	1	Dep	Ca	Ah	18	L	14	Btg	32	C	Massive	BCg	120	CL	Poor-Imp
31	10	3	COR	COR1/1	HU.LG	CL Till	1	Up	Cv	Ah	17	L	8	Btg	25	C	Massive	Csak	80	CL	Poor-Imp
32	9	3	HGT	COR1/1	O.HG	Cl Till	0	Dep	Ca	Ahg	30	CL	10	Btg	40	C	Massive	BCg	120	CL-C	V. Poor
33	8	3	COR	COR1/3	HU.LG	C Lac	0	Dep	Ca	Ahg	27	L	10	Btg	37	C	Massive	BCg	120	CL-C	Poor
34	7	3	DYD	FMN1/3	BL.SO	CL Till	3	Mid	Cv	Ap	22	L	10	Btnj	32	CL	Mod Med Pr	Csk	90	CL	Mod Well
35	6	3	DYD	FMN1/3	BL.SO	CL Till	3	Mid	Cv	Ap	23	L	14	Btnj	37	CL	Mod Med Pr	Csk	80	CL	Well
36	5	3	DYD	KLM1/2	BL.SO	CL Till	3	Mid	Cv	Ap	15	L	20	Btnj	35	CL-C	Mod Med Pr	Csk	90	CL	Well

Table A2.1 Grid soil survey site observation data

							Type of Slope			A-horizon desc				B-horizon Description				C-horizon Desc			Profile
Site No.	Row (x)	Col (y)	Ser Code	Map Unit	Soil SubG	Type of PM	%	Pos	Shape	Type	Dep	Text	Th	Type	Dep	Text	Structure	Type	Dep	Text	Drainage Class
37	4	3	DYD	DYD1/2	BL.SO	Cl Till	3	Up	Cv	Ap	18	L	12	Btnj	30	CL	St Med Blk	Csk	60	CL	Well
38	3	3	DYD	DYD1/2	BL.SO	CL Till	2	Up	Cv	Ap	17	L	8	Btnj	25	CL	St Med Blk	Csk	65	CL	Well
39	2	3	DYD	DYD1/3	BL.SO	CL Till	2	Up	Cv	Ap	14	L	3	Btjnj	17	CL	Mod Med Pr	Csk	45	CL	Well
40	1	3	FMN	FMN1/2	SZ.LG	CL Till	2	Low	Cv	Ap	15	L	0	Bntgj	15	C	St Med Blk	Csakg	90	CL	Imp-Poor
41	1	5	DYD	DYD1/3	BL.SO	CL Till	4	Up	Cv	Ap	15	L-SL	10	Btjnj	25	CL	St Med Blk	Csk	45	CL	Well-Mod
42	2	5	KLM	KLM1/2	BL.SS	CL Till	4	Up	Cv	Ap	15	L	0	Bnt	15	CL-C	St Med Col	Csk	60	CL	Well
43	3	5	KLM	KLM1/2	BL.SS	CL TIll	2	Cr	Cv	Ap	15	L	7	Btnj	22	CL-C	St Med Col	Csk	80	CL	Well
44	4	5	KLM	KLM1/2	BL.SS	CL Till	5	Up	Cv	Ap	15	L	7	Btnj	22	CL-C	St Med Blk	Csk	65	CL	Well
45	5	5	KLM	KLM1/2	BL.SS	CL Till	5	Up	Cv	Ap	16	L	0	Bnt	16	C	St Med Blk	Csk	65	CL	Well
46	6	5	KLM	KLM1/2	BL.SS	CL Till	2	Cr	Cv	Ap	14	L	0	Bnt	14	C	St Med Col	Csk	65	CL	Well
47	7	5	KLM	KLM1/3	BL.SS	CL Till	4	Up	Cv	Ap	15	L	7	Bnt	22	CL-C	St Med Blk	Csk	65	CL	Well
48	8	5	KLM	KLM1/3	BL.SS	CL Till	3	Up	Cv	Ap	15	L	5	Bnt	20	C-CL	St Med Col	Csk	55	CL	Well
49	9	5	KLM	KLM1/3	BL.SS	CL Till	3	Mid	Cv	Ap	16	L	7	Bnt	23	C	St Med Col	Csk	100	CL	Well
50	10	5	KLM	KLM1/3	BL.SS	CL Till	3	Low	Cv	Ap	15	L	5	Btnj	20	CL	St Med Col	Csk	55	CL	Well
51	11	5	KLM	KLM1/3	BL.SO	CL Till	4	Low	Cv	Ap	15	L	7	Bnt	22	C	St Med Col	Csk	70	CL	Well
52	12	5	DYD	KLM1/3	BL.SS	CL Till	5	Mid	Cv	Ap	15	L	8	Btnj	23	CL	Mod Med Blk	Csk	60	CL	Well
53	13	5	KLM	KLM1/3	BL.SS	CL Till	4	Up	Cv	Ap	16	L	6	Bnt	22	C	St Med Col	Csk	75	CL	Well
54	14	5	KLM	KLM1/3	BL.SS	CL Till	2	Up	Cv	Ap	15	L	6	Btnj	21	CL	Mod Med Col	Csk	55	CL	Well
55	15	5	EOR	EOR1/2	O.BL	CL Till	4	Up	Cv	Ap	14	L	0	Bm	14	CL	Weak Med Pr	Csk	55	CL	Well
56	16	5	KLM	EOR1/2	BL.SS	CL Till	2	Cr	Cv	Ap	15	CL	0	Bnt	15	C	St Med Col	Csak	60	CL	Mod Well
57	17	5	DYD	KLM1/3	BL.SO	CL Till	3	Mid	Cv	Ap	20	L	5	Btjnj	25	CL	Mod Med Blk	Csak	75	CL	Well
58	18	5	COR	COR1/3	HU.LG	CL Till	3	Low	Ca	Ap	18	L	12	Btg	30	C	Massive	Ckg	70	CL	Imp-Poor
59	19	5	COR	COR1/1	HU.LG	C Lac	1	Dep	Ca	Ah	23	L	10	Btg	33	C	Massive	BCg	120	CL-C	V. Poor
60	20	5	EOR	EOR1/3	O.BL	CL Till	3	Mid	Cv	Ap	18	L	2	Bm	20	CL	Mod Fin SAB	Ck	47	CL	Well
61	1	7	EOR	EOR1/2	O.BL	CL Till	3	Mid	Cv	Ap	20	L	0	Bm	20	CL	Mod Med SAB	Ck	65	CL	Well
62	2	7	DYD	EOR1/3	BL.SO	CL Till	3	Mid	Cv	Ap	16	L	0	Btnj	16	CL-C	Mod Med Col	Ccasa	60	CL	Well
63	3	7	DYD	EOR1/3	BL.SO	CL Till	4	Mid	Cv	Ap	15	L	5	Btnj	20	CL-C	St Med Col	Ccasa	45	CL	Well
64	4	7	KLM	KLM1/3	BL.SS	CL Till	4	Mid	Cv	Ap	15	L	7	Btnj	24	C-CL	St Med Blk	Ccasa	60	CL	Well
65	5	7	SGK	COR1/3	E.BL	CL Till	5	Low	Cv	Ap	16	L	10	Bt	26	CL-C	Mod Med SAB	Csk	97	CL	Well-Imp
66	6	7	COR	COR1/1	HU.LG	C Lac	1	Toe	Ca	Ap	20	L	12	Btg	32	C	Mod Med SAB	BCg	120	CL	Poor
67	7	7	COR	COR1/3	HU.LG	C Lac	1	Dep	Ca	Ah	22	L-CL	10	Btg	32	C	Massive	BCg	120	CL-C	Poor
68	8	7	SGK	COR1/3	E.BL	CL Till	4	Low	Cv	Ap	15	L	13	Bt	38	CL	St Fin SAB	Ck	75	CL	Well
69	9	7	KLM	KLM1/3	BL.SS	CL Till	3	Up	Cv	Ap	15	L	3	Bntj	18	CL	St Med Col	Csk	55	CL	Well
70	10	7	KLM	KLM1/3	BL.SS	CL Till	3	Up	Cv	Ap	15	L	5	Bntj	25	CL	St Med Col	Ccasa	55	CL	Well
71	11	7	KLM	KLM1/3	BL.SS	CL Till	4	Up	Cv	Ap	15	L	8	Bntj	23	CL	St Med Col	Ccasa	85	CL	Well
72	12	7	KLM	KLM1/3	BL.SS	CL Till	5	Up	Cv	Ap	15	L	3	Bnt	18	CL	St Med Col	Ccasa	104	CL	Well

Table A2.1 Grid soil survey site observation data

							Type of Slope			A-horizon desc				B-horizon Description				C-horizon Desc			Profile
Site No.	Row (x)	Col (y)	Ser Code	Map Unit	Soil SubG	Type of PM	%	Pos	Shape	Type	Dep	Text	Th	Type	Dep	Text	Structure	Type	Dep	Text	Drainage Class
73	13	7	KLM	KLM1/3	BL.SS	CL Till	6	Up	Cv	Ap	15	L	5	Bnt	20	C-CL	St Crs Col	Ccasa	76	CL	Well
74	14	7	EOR	EOR1/2	O.BL	CL Till	6	Up	Cv	Ap	18	L	3	Btjnj	21	CL	Weak Med Pr	Csk	57	CL	Well
75	15	7	EOR	EOR1/2	O.BL	CL Till	2	Cr	Cv	Ap	15	L	0	Bm	15	L	Weak Med Pr	Ck	50	CL-L	Well
76	16	7	EOR	EOR1/2	O.BL	CL Till	2	Cr	Cv	Ap	15	L	0	Bm	15	L	Weak Med Pr	Ck	60	CL	Well
77	17	7	EOR	EOR1/2	O.BL	CL Till	3	Cr	Cv	Ap	15	L	0	Bm	15	L	Weak Med Pr	Ck	54	CL	Well
78	18	7	HER	EOR1/2	SZ.BL	CL Till	2	Up	Cv	Ap	15	L	4	Btnj	19	CL	Mod Med Col	Ccasa	58	CL	Well
79	19	7	DYD	EOR1/2	BL.SO	CL Till	3	Up	Cv	Ap	15	L	5	Bntj	20	C	St Med Col	Ccasa	104	CL	Well
80	20	7	KLM	KLM1/3	BL.SS	CL Till	4	Up	Cv	Ap	15	L	2	Bnt	17	C	St Med Col	Ccasa	60	CL	Well
81	20	9	HER	KLM1/3	SZ.BL	CL Till	3	Mid	Cv	Ap	15	L	0	Btnj	15	L-CL	Mod Med Pr	Cca	65	CL	Well
82	19	9	DYD	KLM1/3	BL.SO	CL Till	3	Mid	Cv	Ap	15	L	9	Btnj	24	CL	Mod Med Col	Ccasa	60	CL	Well
83	18	9	KLM	KLM1/3	BL.SS	CL Till	4	Mid	Cv	Ap	16	L	7	Bnt	23	C	St Med Col	Ccasa	55	CL	Well
84	17	9	DYD	KLM1/3	BL.SO	CL Till	4	Up	Cv	Ap	19	L	10	Btnj	29	C	Mod Med Col	Ccasa	55	CL	Well
85	16	9	EOR	EOR1/2	O.BL	CL Till	5	Mid	Cv	Ap	15	L	10	Bm	25	L	Weak Med Pr	Ck	50	CL	Well
86	15	9	KLM	KLM1/3	BL.SS	CL Till	6	Mid	Cv	Ap	16	L	8	Bnt	29	C	St Med Col	Ccasa	60	CL	Well
87	14	9	SGK	COR1/3	E.BL	CL Till	6	Toe	Ca	Ah	30	L	10	Bt	40	CL	Mod Med Pr	Cca	55	CL	Well
88	13	9	COR	COR1/1	HU.LG	C Lac	1	Dep	Ca	Ah	30	L	10	Btg	40	C-CL	Massive	BCg	120	CL-C	Very Poor
89	12	9	COR	COR1/1	HU.LG	C Lac	1	Dep	Ca	Ah	30	L	10	Btg	40	C-CL	Massive	BCg	120	C-CL	Very Poor
90	11	9	n/a	FMN1/3	R.BL	CL Till	3	Up	Cv	Ap	15	L	0	None	0	n/a	n/a	Ck	15	CL	Mod Well
91	10	9	FMN	FMN1/3	SZ.LG	C Lac	2	Toe	Cv	Ap	20	CL	0	ACcasa	20	C	Massive	Csakg	35	CL	Poor-Imp
92	9	9	FMN	FMN1/2	SZ.LG	C Lac	2	Toe	Cv	Ap	20	CL	1	ACcasa	20	C	Massive	Csakg	29	C	Poor
93	8	9	COR	COR1/1	HU.LG	C Lac	1	Dep	Ca	Ah	27	L	12	Btg	44	C	Massive	BCg	120	C-CL	Poor
94	7	9	COR	COR1/1	HU.LG	C Lac	1	Dep	Ca	Ah	30	L	10	Btg	40	C	Massive	Ccag	100	CL	Poor
95	6	9	COR	COR1/1	HU.LG	C Lac	1	Dep	Ca	Ah	28	L	15	Btg	43	C	Massive	BCg	120	CL	Poor
96	5	9	FMN	KLM1/3	SZ.LG	CL Till	6	Low	Cv	Ap	20	L	0	Bn	28	C	Massive	Ccasag	60	CL	Poor-Imp
97	4	9	EOR	EOR1/3	SZ.LG	CL Till	6	Up	Cv	Ap	15	L	0	Bm	15	CL-L	Weak Med Pr	Ck	65	CL	Well
98	3	9	EOR	EOR1/3	O.BL	CL Till	3	Up	Cv	Ap	15	L	0	Bm	15	L-CL	Weak Med Pr	Ck	50	CL	Well
99	2	9	COR	COR1/2	HU.LG	CL Till	1	Dep	Ca	Ap	20	L	12	Btg	32	CL	Massive	BCg	120	CL	Poor-Imp
100	1	9	EOR	EOR1/3	O.BL	CL Till	2	Toe	Cv	Ap	20	L	0	Bm	20	L-CL	Weak Med Pr	Ck	65	CL	Well
101	20	13	LFN	COR1/3	GLE.BL	CL Till	3	Low	Cv	Ap	19	L	4	Btgj	23	CL	Wk Med SAB	Ck	50	CL	Mod Well
102	19	13	LFN	COR1/3	GLE.BL	CL Till	2	Mid	Cv	Ap	22	L	0	Bm	22	L-CL	Weak Med Pr	Ck	44	CL	Well-Imp
103	18	13	COR	COR1/2	HU.LG	C Lac	1	Dep	Ca	Ap	20	L	20	Btg	40	CL	Massive	BCg	120	CL	Poor
104	17	13	LFN	COR1/3	GLE.BL	CL Till	2	Low	Cv	Ap	15	L	10	Btgj	25	CL	Mod Med Pr	Ckg	60	CL	Imp
105	16	13	KLM	KLM1/2	BL.SS	CL Till	3	Mid	Cv	Ap	18	L	0	Bnt	15	C	St Med Blk	Ccasa	72	CL	Mod Well
106	15	13	EOR	EOR1/2	O.BL	CL Till	3	Up	Cv	Ap	15	L	0	Bm	18	CL-L	Weak Med Pr	Ck	60	CL	Well
107	14	13	KLM	EOR1/2	BL.SS	CL Till	3	Up	Cv	Ap	15	L	5	Bnt	20	CL-C	St Med Col	Ccasa	70	CL	Mod Well
108	13	13	EOR	EOR1/2	O.BL	CL Till	3	Up	Cv	Ap	18	L	0	Bm	18	CL-L	Mod Med Pr	Cca	55	CL	Well

Table A2.1 Grid soil survey site observation data

							Type of Slope			A-horizon desc			B-horizon Description					C-horizon Desc			Profile
Site No.	Row (x)	Col (y)	Ser Code	Map Unit	Soil SubG	Type of PM	%	Pos	Shape	Type	Dep	Text	Th	Type	Dep	Text	Structure	Type	Dep	Text	Drainage Class
109	12	13	n/a	KLM1/2	R.BLca	CL Till	4	Up	Cv	Ap	15	L	0	BC	30	CL	disturbed	Ccasa	105	CL	Well
110	11	13	n/a	KLM1/3	R.BLca	CL Till	4	Low	Cv	Ap	15	L	15	Bnt	30	CL	disturbed	Ccasa	85	CL	Mod Well
111	10	13	KLM	KLM1/2	BL.SS	CL Till	1	Toe	Ca	Ah	20	L	5	Bnt	25	CL	Mod Med Col	Csak	110	CL	Mod Well
112	9	13	KLM	FMN1/2	BL.SS	Cl Till	1	Toe	Ca	Ah	18	L	7	Bnt	25	CL	Mod Med Col	Ccasa	88	CL	Mod Well
113	8	13	FMN	FMN1/2	SZ.LG	CL Till	1	Dep	Ca	Ah	10	L	0	Bntg	20	CL	St Med Blk	Ccasag	30	CL	Imp-Poor
114	7	13	FMN	FMN1/2	SZ.LG	C Lac	1	Dep	Ca	Ah	15	L-CL	0	Bntg	15	C	Massive	Ccasa	55	CL-C	Poor
115	6	13	COR	COR1/2	HU.LG	C Lac	1	Dep	Ca	Ah	17	L	2	Btg	19	C	Weak Med Pr	Ccag	25	CL	Poor
116	5	13	COR	COR1/2	HU.LG	C Lac	1	Dep	Ca	Ah	23	L	10	Btg	33	C	Massive	BCg	120	C-CL	Poor
117	4	13	EOR	DYD1/3	O.BL	CL Till	3	Mid	Ca	Ap	25	L	0	Bm	25	L-SCL	Weak Med Pr	Cca	45	CL	Well
118	3	13	DYD	DYD1/2	BL.SO	CL Till	3	Up	Cv	Ap	17	L	0	Btnj	17	CL	Weak Med Pr	Cca	50	CL	Well
119	2	13	DYD	KLM1/3	BL.SO	CL Till	4	Low	Ca	Ap	20	L	0	Btnj	20	CL	St Med Pr	Cca	65	CL	Well
120	1	13	KLM	KLM1/3	BL.SS	CL Till	4	Low	Ca	Ap	17	L	15	Bnt	32	CL	St Med Col	Ccasa	75	CL	Well-Mod
121	1	15	KLM	KLM1/2	BL.SS	CL Till	3	Up	Cv	Ap	16	L	6	Bnt	22	C	St Med Col	Ccasa	60	CL	Well-Mod
122	2	15	KLM	KLM1/2	BL.SS	CL Till	4	Cr	Cv	Ap	16	L	7	Bnt	23	C-CL	St Med Col	Ccasa	56	CL	Mod Well
123	3	15	DYD	DYD1/3	BL.SO	CL Till	4	Up	Cv	Ap	12	L	8	Btj	20	CL	Mod Med Pr	Ccasa	60	CL	Well
124	4	15	DYD	DYD1/3	BL.SO	CL Till	5	Up	Cv	Ap	18	L	12	Btnj	30	CL	Mod Med Pr	Ccasa	85	CL	Well
125	5	15	DYD	DYD1/3	BL.SO	CL Till	5	Low	Cv	Ap	16	L	7	Btnj	23	CL	Mod Med Blk	Ccasa	67	CL	Mod Well
126	6	15	DYD	DYD1/3	BL.SO	CL Till	5	Low	Cv	Ap	15	L	8	Btnj	23	CL	Mod Med Blk	Cca	80	CL	Mod Well
127	7	15	DYD	DYD1/3	BL.SO	CL Till	5	Mid	Cv	Ap	18	L	2	Btnj	20	CL	St Med Col	Cca	40	CL	Mod Well
128	8	15	EOR	DYD1/4	O.BL	CL Till	6	Mid	Cv	Ap	20	L	0	Bm	20	L-CL	Weak Med Pr	Cca	60	CL	Well
129	9	15	EOR	DYD1/4	O.BL	CL Till	6	Mid	Cv	Ap	26	L	0	Bm	26	L-CL	Weak Med Pr	Cca	60	CL	Well
130	10	15	DYD	DYD1/4	BL.SO	CL Till	5	Mid	Cv	Ap	18	L	0	Btnj	18	CL	Mod Med Col	Ccasa	65	CL	Mod Well
131	11	15	DYD	DYD1/3	BL.SO	CL Till	6	Mid	Cv	Ap	15	L	9	Btnj	24	CL	St Fine Blk	Ccasa	90	CL	Mod Well
132	12	15	EOR	DYD1/3	O.BL	CL Till	4	Mid	Cv	Ap	18	L	0	Bm	18	L	Wk Fine SAB	Cca	65	CL	Well
133	13	15	COR	COR1/3	HU.LG	C Lac	1	Toe	Ca	Ah	10	L	6	Btg	16	C-CL	Massive	Cca	64	CL	Poor
134	14	15	COR	COR1/1	HU.LG	C Lac	1	Dep	Ca	Ah	20	L	18	Btg	38	CL	Massive	BCg	110	CL-L	Poor
135	15	15	SGK	COR1/3	E.BL	CL Till	1	Low	Cv	Ah	23	L	7	Bt	30	CL	Wk Med SAB	Ck	86	CL	Well-Mod
136	16	15	KLM	KLM1/2	BL.SS	CL Till	2	Up	Cv	Ap	20	L	5	Bnt	25	C	St Med Col	Ccasa	95	CL	Mod Well
137	17	15	DYD	KLM2/2	BL.SO	CL Till	2	Up	Cv	Ap	30	L	8	Btnj	38	CL	St Med Pr	Ccasa	80	CL	Mod Well
138	18	15	DYD	KLM2/2	BL.SO	CL Till	2	Up	Cv	Ap	26	L	4	Btnj	30	CL	St Med Col	Ccasa	44	CL	Mod Well
139	19	15	HER	KLM2/2	SZ.BL	CL Till	2	Up	Cv	Ap	18	L	0	Btnj	18	CL	St Med Blk	Ccasa	87	CL	Well
140	20	15	n/a	KLM1/3	R.BLca	CL Till	2	Mid	Cv	Ap	15	L	0	none	15	n/a	n/a	Ck	15	CL	Mod Well
141	20	17	HER	DYD1/2	SZ.BL	CL till	2	Up	Cv	Ap	20	L	0	Bm	20	L-CL	Weak Med Pr	Ccasa	37	CL	Well
142	19	17	DYD	DYD1/2	BL.SO	CL Till	2	Up	Cv	Ap	20	L	8	Btnj	28	CL	Mod Med Pr	Ccasa	95	CL	Mod Well
143	18	17	DYD	DYD1/2	BL.SO	CL Till	3	Mid	Cv	Ap	19	L	7	Btnj	26	CL-L	Mod Med Blk	Cca	54	CL	Mod Well
144	17	17	KLM	DYD1/2	BL.SS	CL Till	4	Up	Cv	Ap	18	L	0	Bnt	18	CL-C	Mod Med Col	Ccasa	55	CL	Mod Well

Table A2.1 Grid soil survey site observation data

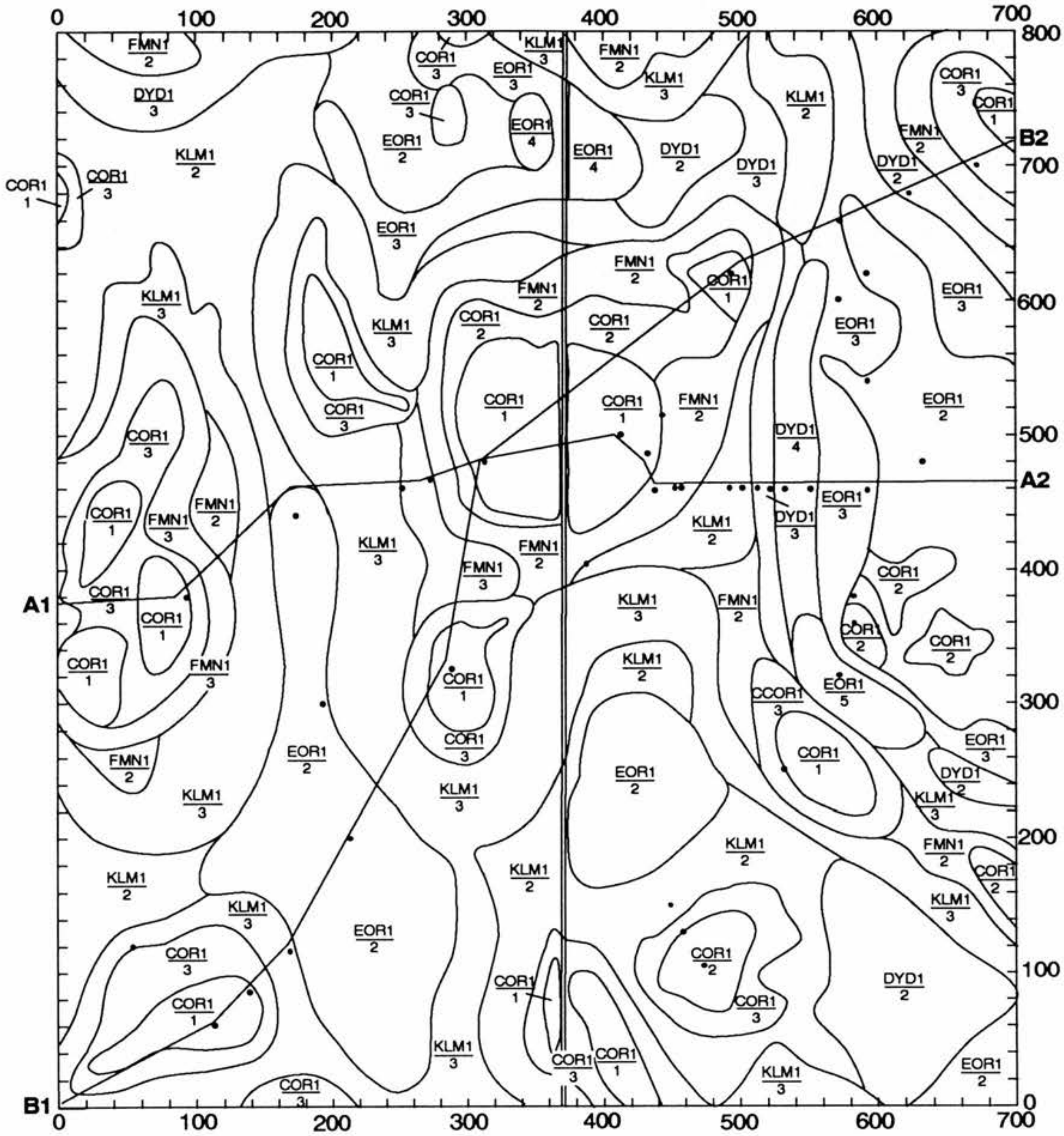
							Type of Slope			A-horizon desc			B-horizon Description					C-horizon Desc			Profile
Site No.	Row (x)	Col (y)	Ser Code	Map Unit	Soil SubG	Type of PM	%	Pos	Shape	Type	Dep	Text	Th	Type	Dep	Text	Structure	Type	Dep	Text	Drainage Class
145	16	17	KLM	KLM1/3	BL.SS	CL Till	3	Mid	Cv	Ap	22	L	8	Bnt	30	C	St Med Col	Ccasa	45	CL	Mod Well
146	15	17	SGK	COR1/3	E.BL	CL Till	4	Toe	Cv	Ap	30	L	0	Btj	30	CL	Wk Med SAB	Cca	50	CL	Well
147	14	17	KLM	KLM1/3	BL.SS	CL Till	4	Mid	Cv	Ap	28	L	9	Bnt	37	C-CL	St Med Col	Ccasa	72	CL	Mod Well
148	13	17	EOR	EOR1/5	O.BL	CL Till	3	Low	Ca	Ah	40	L	0	Bm	40	L	Wk Med SAB	Cca	95	CL	Well
149	12	17	EOR	EOR1/2	O.BL	CL Till	2	Up	Cv	Ap	15	L	5	Bm	20	L-CL	Wk Fine SAB	Cca	55	CL	Mod Well
150	11	17	COR	COR1/2	HU.LG	CL Till	1	Dep	Ca	Ap	15	L	7	Btg	22	CL-C	Massive	Cca	95	CL	Poor-Imp
151	10	17	HER	EOR1/2	SZ.BL	CL Till	1	Low	Cv	Ap	21	L	4	Btnj	25	CL	St Med SAB	Ccasa	98	CL	Mod Well
152	9	17	EOR	EOR1/2	O.BL	CL Till	1	Toe	Ca	Ap	20	L	5	Bm	25	CL-C	Wk Fine SAB	BC	120	CL	Well
153	8	17	KLM	EOR1/2	BL.SS	CL Till	2	Low	Cv	Ap	15	L	4	Bnt	19	C-CL	St Med Col	Ccasa	70	CL	Mod Well
154	7	17	EOR	EOR1/2	O.BL	CL Till	2	Low	Ca	Ap	18	L	0	Bm	18	L-CL	Weak Med Pr	Cca	90	CL	Well
155	6	17	DYD	EOR1/3	BL.SO	CL Till	3	Up	Cv	Ap	18	L	5	Btnj	23	CL	St Crs Pr	Cca	70	CL	Well
164	4	19	FMN	FMN1/3	SZ.LG	CL Till	3	Toe	Cv	Ah	13	L	0	Bntj	13	C	St Med Blk	Ccasa	50	CL	Mod Well
165	5	19	KLM	DYD1/2	BL.SS	CL Till	5	Low	Cv	Ap	15	L	2	Bnt	17	C-CL	St Med Col	Ccasa	83	CL	Mod Well
166	6	19	EOR	EOR1/3	O.BL	CL Till	5	Up	Cv	Ap	20	L	0	Bm	20	L-CL	Weak Med Pr	Cca	80	CL	Well
167	7	19	DYD	EOR1/2	BL.SO	CL Till	3	Up	Cv	Ap	15	L	4	Btnj	19	CL-C	Mod Med Col	Ccasa	50	CL	Mod Well
168	8	19	EOR	EOR1/2	O.BL	CL Till	2	Up	Cv	Ap	17	L	0	Bm	17	L-CL	Weak Med Pr	Cca	54	CL	Well
169	9	19	EOR	EOR1/2	O.BL	CL Till	3	Up	Cv	Ap	19	L	0	Bm	19	CL-L	Mod Med Pr	Cca	66	CL	Well
170	10	19	DYD	EOR1/2	BL.SO	CL Till	3	Low	Ca	Ap	18	L	0	Btnj	18	CL	Mod Med Pr	Ccasa	50	CL	Mod Well
171	11	19	DYD	EOR1/2	BL.SO	CL Till	2	Low	Ca	Ap	20	L	8	Btnj	28	CL	Mod Med Col	Ccasa	72	CL	Mod Well
172	12	19	DYD	EOR1/2	BL.SO	CL Till	2	Up	Cv	Ap	15	L	0	Btnj	26	CL	Mod Med Pr	Ccasa	65	CL	Well
173	13	19	EOR	EOR1/2	O.BL	CL Till	2	Low	Cv	Ap	17	L	0	Bm	17	CL	St Med SAB	Cca	60	CL	Well
174	14	19	EOR	EOR1/3	O.BL	CL Till	2	Up	Cv	Ap	16	L	0	Bm	16	L-CL	none	Ccasa	54	CL	Well
175	15	19	KLM	KLM1/3	BL.SS	CL Till	3	Low	Cv	Ap	15	L	4	Bnt	19	CL-C	St Med Col	Ccasa	75	CL	Mod Well
176	16	19	COR	COR1/2	HU.LG	CL Till	2	Low	Ca	Ap	25	L	2	Btg	27	C-CL	Massive	BCg	120	CL	Poor
177	17	19	HER	KLM1/3	SZ.BL	CL Till	3	Toe	Ca	Ap	20	L	0	Btjnj	20	CL	Massive	Ccasa	80	CL	Mod Well
178	18	19	HER	KLM1/3	SZ.BL	CL Till	3	Mid	Cv	Ap	15	L	0	Btjnj	15	CL	St Fine SAB	Ccasa	70	CL	Mod Well
179	19	19	EOR	EOR1/2	O.BL	CL Till	3	Mid	Cv	Ap	15	L	0	Bm	15	L-CL	Wk Fine Pr	Cca	85	CL	Well
180	20	19	EOR	EOR1/2	O.BL	CL Till	3	Low	Cv	Ap	19	L	6	Bm	25	CL-L	St Fine SAB	Ccasa	83	CL	Well

APPENDIX 3

SOIL AND HYDROLOGICAL CHARACTERISATION DATA FOR DETAILED SAMPLE SITES

A3.1 Introduction

This appendix contains a listing of all data collected to describe and characterise the hydrological and pedological properties of soils at detailed sampling sites located along cross-sectional transects. The locations of the 2 main transects and of all sites where detailed sampling was conducted are indicated on Figure A3.1. Schematic cross sections (Figures A3.2 & A3.3) illustrate the relative position in the landscape and associated soil for each of the detailed sample sites. Results of field measurement of saturated hydraulic conductivity and bulk density (BD) are listed by site and depth (horizon) in table A3.1. The original field measurements are summarized by Soil Series and depth (horizon) in Table A3.2. The order in which Soil Series are listed in Table A3.2 corresponds to the order in which they occur in the landscape, from highest to lowest landscape position. The corresponding data as recorded in the Alberta Soil Layer File (SLF) (Tajek, personal communication, 1992) are provided for comparison purposes (Table A3.3). All available data for each of the transect sites is collated on a standard soil site description and analytical report form (Table A3.4).



Approximate scale 1:5,500

Figure A3.1 Soil map of the Lunty site showing the location of cross sectional transects

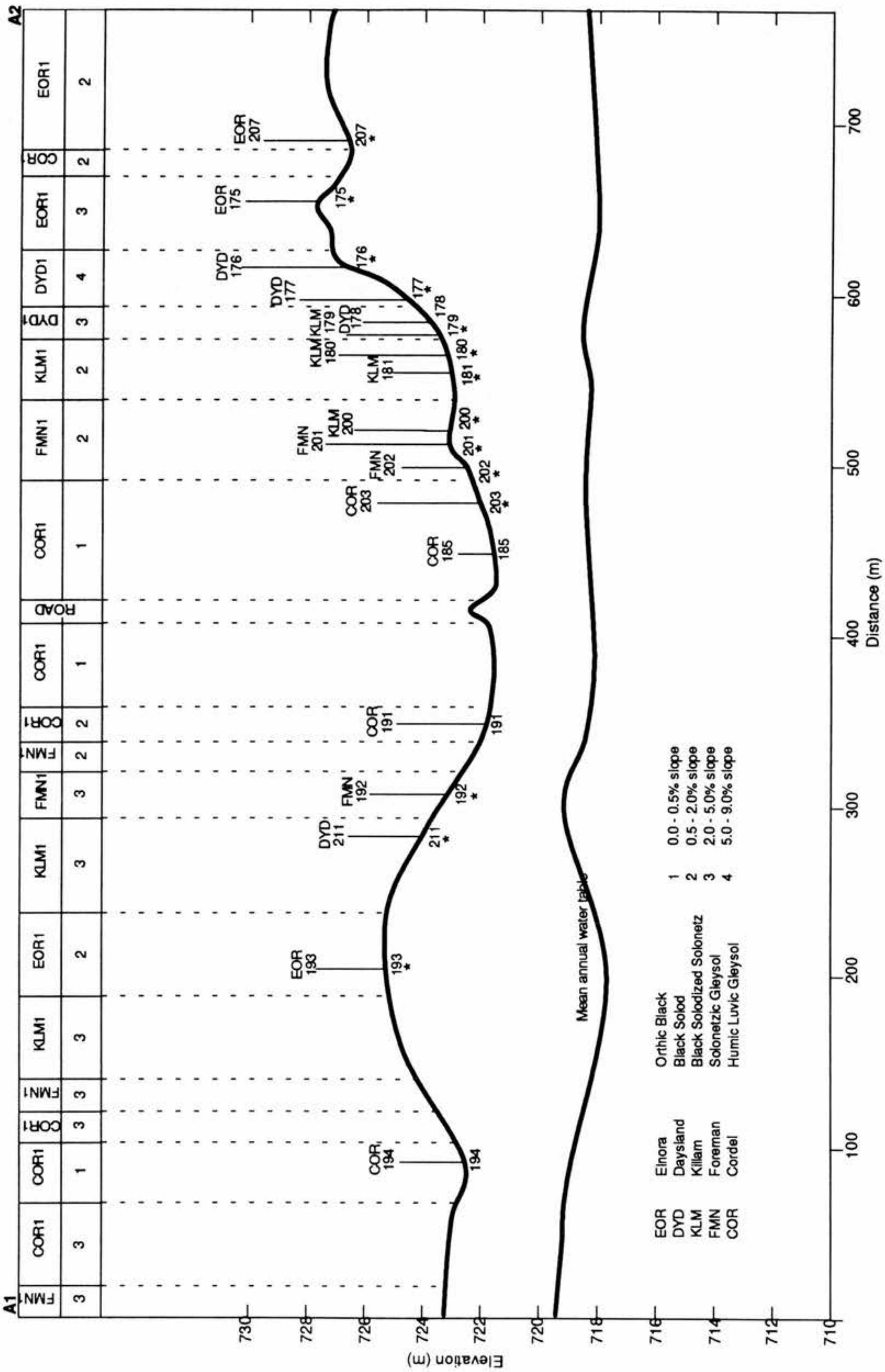


Figure A3.2 Schematic cross section A1-A2 from W-E across the central portion of the Lunty site.

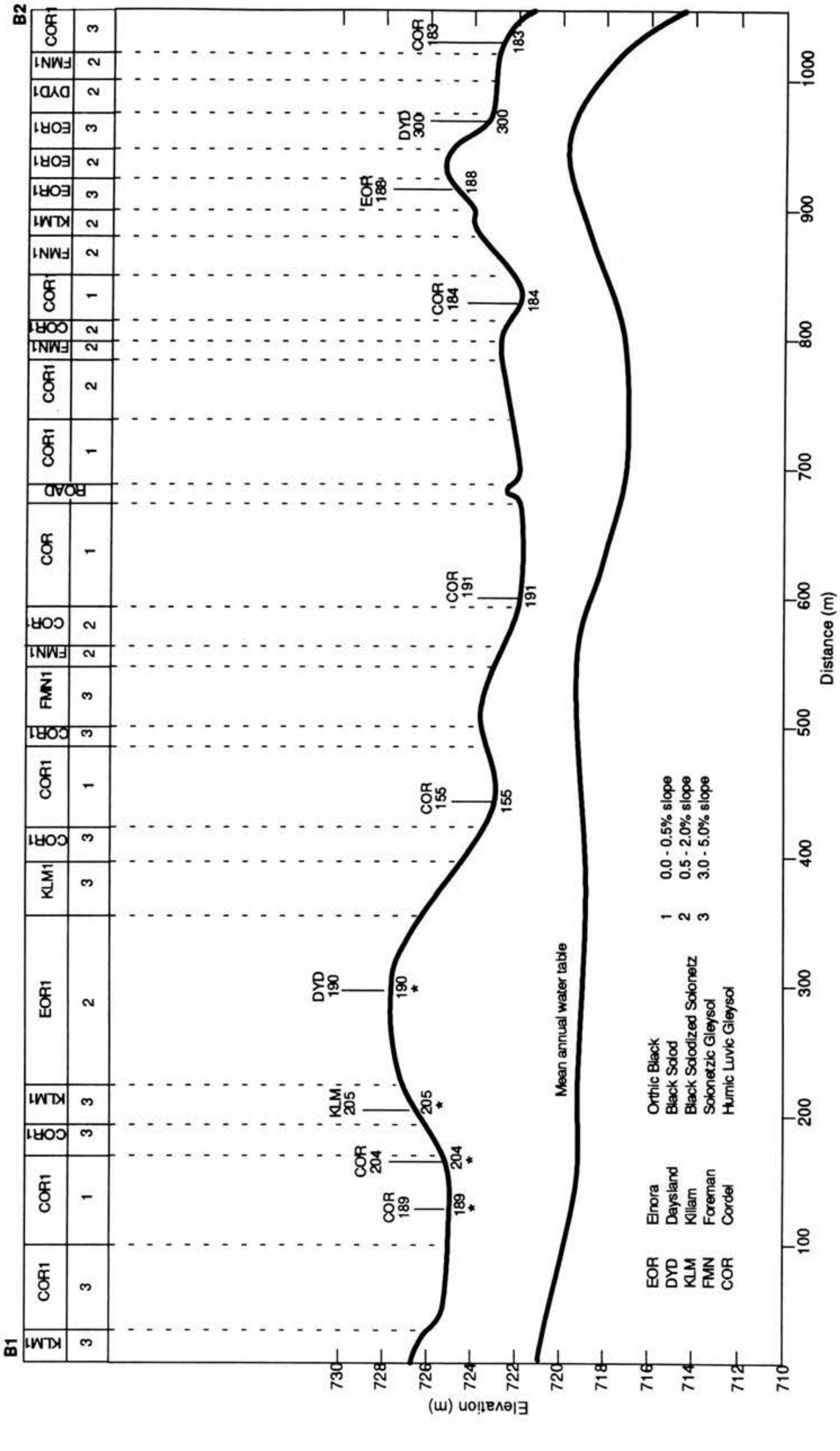


Figure A3.3 Schematic cross section B1-B2 from the SW-NE corner of the Lunty site.

Table A3.1 Field measured bulk density and saturated hydraulic conductivity for selected horizons and depths at Lunty site sampling locations.

Horizon type	Horizon Depth in cm	Saturated hydraulic conductivity mm/hr Test Depth	Numb Tests	K1	K2	K3	Ave KSat	Max KSat	Field bulk density ($gm\ cm^{-3}$) Test Depth	Numb Tests	BD1	BD2	BD3	Ave BD	TP (%)
Site: 154	**Soil Series: KLM**														
Ap	0-20	15	3	1.7	5.8	4.2	3.9	8.7	2- 17	3	1.17	1.14	1.17	1.16	56.2
Ae	20-25														
Bnt	25-47	40	3	1.2	0.8	0.6	0.8	1.3	23- 40	3	1.42	1.50	1.49	1.47	44.5
BCsa	47-68														
Ccasa	68-90								40- 90	3	1.59	1.76	1.73	1.69	36.2
Site: 155	**Soil Series: COR**														
Ah	0-20								5- 13	1	0.84			0.84	68.3
Btg	20-45								35- 42	1	1.28			1.28	51.7
Ckg	45-100								58- 64	1	1.78			1.78	32.8
Site: 175	**Soil Series: EOR**														
Ap	0-10	10	3	0.3	0.5	2.1	1.0	1.8	0- 8	1	1.31			1.31	50.6
Bm	10-30	30	3	2.3	4.7	3.4	3.5	5.3	20- 30	1	1.38			1.38	47.9
Cca1	30-55								35- 45	1	1.26			1.26	52.5
Cca2	55-100								55- 64	1	1.45			1.45	45.3
Site: 176	**Soil Series: DYD**														
Ap	0-11	11	2	0.9	0.8		0.8	1.8	0- 10	1	1.24			1.24	53.2
Bntj	11-36	47	3	0.8	0.6	0.7	0.7	0.9	33- 43	1	1.35			1.35	49.1
BCsa	36-47														
Ccasa	47-100								70- 80	1	1.51			1.51	43.0
Site: 177	**Soil Series: DYD**														
Ap	0-13	17	3	7.9	11.5	12.0	10.5	20.8	5- 14	1	1.20			1.20	54.7
Ah	13-17														
Bm	17-44	44	2					0.1	30- 40	1	1.50			1.50	43.4
Bntj	44-62	62	2	1.4	1.2		1.3	2.1	40- 50	1	1.40			1.40	47.2
BCsa	62-85								70- 80	1	1.37			1.37	48.3
Ccasa	85-100														
Site: 179	**Soil Series: KLM**														
Ap	0-10														
Aheb	10-30	30	3	1.2	1.4	1.3	1.3	1.9	10- 19	1	0.76			0.76	71.3
Bnt	30-49	50	2	0.1	0.1		0.1	0.1	30- 38	1	1.19			1.19	55.1
BCsa	49-70								50- 60	1	1.38			1.38	47.9
Ccasag	70-100								85- 95	1	1.80			1.80	32.1
Site: 180	**Soil Series: KLM**														
Ap	0-10								5- 15	1	1.09			1.09	58.9
Ahegj	10-20	20	3	1.1	3.1	4.7	3.0	4.4							
Bnt	20-38	38	3	0.3	0.8	0.2	0.4	0.8	28- 35	1	1.52			1.52	42.6
BCsa	38-60								41- 50	1	1.64			1.64	38.1
Ccasa	60-100														
Site: 181	**Soil Series: KLM**														
Ah	0-14								5- 13	1	1.07			1.07	59.6
Ahegj	14-25	25	3	1.0	0.9	1.3	1.1	1.5							
Bnt	25-40	40	3	0.1	0.1	0.2	0.1	0.1	20- 30	1	1.30			1.30	50.9
BCsa	40-68								40- 48	1	1.50			1.50	43.4
Ccasag	68-100								62- 70	1	1.66			1.66	37.4
Site: 182	**Soil Series: COR**														
Ah	0-24								0- 24						
Aeg	24-30								24- 30						
Btg	30-68								30- 68						
BCg	68-100								68-100						

continued ...

Table A3.1 Continued.

Horizon type	Horizon Depth in cm	Saturated hydraulic conductivity mm/hr Test Depth	Numb Tests	K1 K1	K2 K2	K3 K3	Ave KSat	Max KSat	Field bulk density (gm cm^{-3}) Test Depth	Numb Tests	BD1	BD2	BD3	Ave BD	TP (%)
Site: 183	**Soil Series: COR**														
Ah	0-20	20	3	13.7	15.5	15.8	15.0	23.8	2- 10	1	1.25			1.25	52.8
Btg	20-38	35	3	0.1	0.2	0.6	0.3	0.4	25- 35	1	1.52			1.52	42.6
BCg	38-100								60- 70	1	1.55			1.55	41.5
Site: 184	**Soil Series: COR**														
Ah	0-15								0- 15						
Bg	15-41								15- 41						
BCg	41-100								41-100						
Site: 188	**Soil Series: EOR**														
Ap	0-13	12	3	7.9	11.5	16.8	12.1	23.1	0- 7	1	1.23			1.23	53.6
Btnj	13-36	30	2	0.8	1.3		1.0	1.8	20- 30	1	1.47			1.47	44.5
BCsa	36-50								40- 50	1	1.33			1.33	49.8
Ccasa	50-100								55- 65	1	1.50			1.50	43.4
Site: 189	**Soil Series: COR**														
Ah	0-11								3- 11	1	0.99			0.99	62.6
Aheg	11-20	17	3	0.3	0.3	0.3	0.3	0.6	11- 20	1	1.20			1.20	54.7
Btg	20-45	40	2	0.1	0.1		0.1	0.1	25- 35	1	1.40			1.40	47.2
Ccag	45-100								40- 50	1	1.32			1.32	50.2
Site: 190	**Soil Series: DYD**														
Ap	0-12	15	3	2.4	2.0	1.7	2.0	4.2	2- 12	4	0.99	0.83	1.29	1.10	58.5
Ae	12-22														
Btnj	22-50	40	3	3.1	5.8	5.4	4.8	6.5	30- 40	4	1.47	1.42	1.40	1.45	45.3
BCsa	50-64	70	3	6.1	6.8	5.4	6.1	8.8							
Ccasa	64-100								70- 80	4	1.64	1.54	1.64	1.60	39.6
Site: 191	**Soil Series: COR**														
Ah	0-20								5- 15	1	1.03			1.03	61.1
Btg	20-40								30- 40	1	1.55			1.55	41.5
Cskg	40-100								53- 58	1	2.28			2.28	0.0
Site: 192	**Soil Series: FMN**														
Ap	0-15	15	3	0.5	1.4	1.1	1.0	2.1	5- 12	1	1.64			1.64	38.1
Bngk	15-25	25	2	0.1	0.2		0.2	0.4							
BCsakg	25-44								25- 32	1	2.21			2.21	16.6
Ccasag	44-100								50- 59	1	1.77			1.77	33.2
Site: 193	**Soil Series: EOR**														
Ap	0-12	17	2	12.6	19.7		16.1	26.8	3- 15	1	1.38			1.38	47.9
Bm1	12-17	17	1	7.9			7.9	19.4							
Ahb	17-30	30	3	19.8	23.0	12.6	18.5	35.5							
Bm2	30-47	47	3	19.8	36.0	29.9	28.6	51.6	30- 40	1	1.51			1.51	43.0
Ccasa	47-100								65- 75	1	1.49			1.49	43.8
Site: 194	**Soil Series: COR**														
Ah	0-18								0- 18						
Btg	18-45								18- 45						
BCg	45-100								45-100						
Site: 200	**Soil Series: KLM/g**														
Ah	0-10								5- 12	1	1.15			1.15	56.6
Aheg	10-16	15	3	0.5	0.5	0.7	0.6	1.2							
Bnt	16-27								20- 30	1	1.23			1.23	53.6
Bntsa	27-44	43	3	0.3	0.4	0.6	0.5	0.7							
BCgsa	44-60								40- 50	1	1.56			1.56	41.1
Ccasag	60-100								60- 70	1	1.57			1.57	40.8

continued ...

Table A3.1 Continued.

Horizon type	Horizon Depth in cm	Saturated hydraulic conductivity mm/hr Test Depth	Numb Tests	K1	K2	K3	Ave KSat	Max KSat	Field bulk density (gm cm^{-3}) Test Depth	Numb Tests	BD1	BD2	BD3	Ave BD	TP (%)
Site: 201	**Soil Series: FMN**														
Ah	0-10	13	3	0.1	0.1	0.5	0.3	0.5	5- 12	1	1.14			1.14	57.0
Ahe	10-12														
Bn	12-24														
Bnt	24-35	33	2	0.2	0.5		0.4	0.5	20- 30	1	1.18			1.18	55.5
Ccasag	35-100								80- 88	2	1.84	1.67		1.75	34.0
Site: 202	**Soil Series: FMN**														
Ah	0-11	13	2	6.1	13.7		9.9	18.4	0- 10	1	1.01			1.01	61.9
Aheg	11-13	13	1	0.4			0.4	1.0							
Bntg1	13-20														
Bntg2	20-40	40	2	2.3	0.9		1.6	2.2	20- 30	1	1.47			1.47	44.5
Ccasag	40-100								50- 60	2	1.56	1.70		1.63	38.5
Site: 203	**Soil Series: COR**														
Ah	0-18	16	3	0.1	0.1	0.6	0.2	0.3	5- 12	1	1.30			1.30	50.9
Aeg	18-33	32	2	0.1	0.1			0.1	20- 28	1	1.74			1.74	34.3
Btg	33-50								35- 45	1	1.42			1.42	46.4
BCg	50-100														
Site: 204	**Soil Series: COR**														
Ap	0-16	13	3	1.6	1.6	4.7	2.6	5.0	7- 14	5	0.89	1.07	0.93	0.95	64.2
Ae	16-30								21- 28	1	1.87			1.87	29.4
Btg	30-60	40	3	0.2	0.4	0.4	0.3	0.5	48- 58	4	1.64	1.62	1.49	1.57	40.8
BCg	60-100								60- 70	6	1.64	1.54	1.84	1.69	36.2
Site: 205	**Soil Series: KLM**														
Ap	0-13	15	3	4.3	1.5	6.8	4.2	7.0	0- 10	4	0.82	0.95	1.01	0.97	63.4
Ae	13-20														
Btnj	20-50	40	3	0.4	0.4	0.3	0.4	0.6	22- 32	4	1.49	1.54	1.25	1.46	44.9
Bntsa	50-60														
Ccasa	60-100	70	3	9.4	12.6	13.3	11.8	16.6	60- 70	4	1.40	1.23	1.44	1.38	47.9
Site: 207	**Soil Series: EOR**														
Ap	0-14	14	3	4.0	4.7	6.6	5.1	9.1	2- 10	1	1.29			1.29	51.3
Btj	14-44	39	3	9.4	15.8	10.4	11.9	17.0	25- 35	1	1.49			1.49	43.8
Bm	44-84	60	3	28.1	19.4	11.5	19.7	34.7	52- 57	1	1.85			1.85	30.2
Cca	84-100								79- 88	1	1.68			1.68	36.6
Site: 211	**Soil Series: DYD**														
Ap	0-15	17	2	22.0	6.8		14.4	22.3	0- 8	1	1.00			1.00	62.3
Ae	15-17	17	1	1.0			1.0	2.3							
Bntj1	17-33	33	2	0.1	0.1		0.1	0.2	30- 37	1	1.51			1.51	43.0
Bntj2	33-50	50	2	0.1	0.1			0.1							
BCsa	50-72								55- 65	1	1.69			1.69	36.2
Ccasa	72-100														
Site: 300	**Soil Series: DYD**														
Ap	0-14	15	3	4.0	11.5	20.4	12.0	18.6	3- 10	1	1.38			1.38	47.9
Bnt	14-42	40	1	15.5			15.5	24.1	27- 37	1	1.59			1.59	40.0
Ccasag	42-100								60- 69	1	1.77			1.77	33.2

Table A3.2 Summary of field measured bulk density and hydraulic conductivity data by Soil Series and horizon.

		Saturated Hydraulic Conductivity mm/hr				Bulk Density gm cm^{-3}				TP (%)	
Horizon type	**Horizon depth (cm)**	**Min Val**	**Max Val**	**Ave Val**	**No. Test**	**Min Val**	**Max Val**	**Ave Val**	**No. Test**	**Min Val**	**Max Val**
Soil Series: EOR											
Ap	0-12	0.30	19.70	7.9	11	1.23	1.38	1.30	4	48	54
Bm	13-34	2.30	29.90	16.9	13	1.38	1.85	1.45	5	30	48
Btnj	34-40	0.80	15.80	6.8	4	1.47	1.49	1.48	2	43	44
BCsa	40-60					1.33		1.33	1		
Ccasa	60-100					1.45	1.68	1.53	4	37	45
Soil Series: DYD											
Ap	0-14	0.10	21.90	6.5	13	0.83	1.29	1.10	7	51	69
Ae	14-18	1.00	1.00	1.0	1						
AB/Bm	18-25	0.10	0.10	0.1	4	1.50	1.51	1.50	2	43	44
Bntj	25-48	0.04	5.80	1.6	12	1.35	1.51	1.45	7	32	43
BCsa	48-62	5.40	6.80	6.1	3	1.37	1.69	1.53	2	36	48
Ccasa	62-100					1.54	1.64	1.60	3	40	42
Soil Series: KLM											
Ap	0-13	1.50	6.80	4.1	6	0.82	1.38	1.10	10	48	69
Ahegj	13-22	0.50	4.70	1.5	12	1.19	1.59	1.41	11	40	55
Bnt	22-45	0.02	1.15	0.4	18	1.38	1.66	1.56	4	37	48
BCsa	45-65					1.26	1.76	1.51	8	34	52
Ccasa	65-100										
Soil Series: FMN											
Ap	0-10	0.10	13.70	2.9	8	1.01	1.64	1.26	3	38	62
Ahegsk	13-14	0.40		0.4	1	1.18	1.47	1.32	2	45	56
Bngtj	14-27	0.20	2.30	0.7	6		2.21		1		
BCsakg	27-40					1.56	1.84	1.70	5	31	41
Ccasag	40-100										
Soil Series: COR											
Ah	0-18	0.10	15.80	6.0	9	0.84	1.25	1.03	10	51	68
Aheg	18-25	0.10	0.30	0.3	5	1.20	1.20	1.20	1	55	55
Aeg	25-28	0.10	0.30	0.3	5	1.74	1.87	1.80	2	32	52
Btg	28-48	0.10	0.60	0.3	8	1.28	1.64	1.50	8	38	52
BCg	48-95					1.54	1.84	1.69	6	31	42
Ccag	95-100										

Table A3.3 Typical values for soil hydrological properties as estimated in the Alberta Soil Layer File for the main soil series at the Lunty site.

Horizon Type	Horizon Depth (cm)	Ksat mm/hr	KPO vol (%)	KP33 vol (%)	KP1500 vol (%)	Bulk Density g/cc	Total Porosity (%)
Soil Series: EOR							
Ap	0-15	10.000	48	28	19	1.30	51
Bm1	15-30	30.000	48	28	15	1.30	51
Bm2	30-60	30.000	52	29	13	1.40	47
Ck1	60-80	10.000	56	20	12	1.50	43
Ck2	80-130	3.000	56	19	12	1.50	43
Soil Series: DYD							
Ah	0-14	10.000	44	24	14	1.20	55
Ae	14-25	10.000	48	16	7	1.30	51
AB	25-35	10.000	52	21	13	1.40	47
Bnt	35-55	0.300	59	31	20	1.60	40
Csak	55-70	3.000	56	23	14	1.50	43
Csk	70-100	3.000	56	20	12	1.50	43
Soil Series: KLM							
Ap	0-13	1.000	48	25	16	1.30	51
Ae	13-18	3.000	48	16	8	1.30	51
Bnt1	18-32	0.300	59	30	20	1.60	40
Bnt2	32-50	0.100	59	25	16	1.60	40
Csk1	50-80	3.000	56	21	12	1.50	43
Soil Series: FMN							
Ah	0-10	10.000	58	37	25	1.10	58
Ahksgj	10-25	10.000	58	36	25	1.10	58
AC	25-40	3.000	55	29	20	1.20	55
Cskg	40-80	3.000	47	33	23	1.40	47
Cskg	80-100	3.000	47	22	14	1.40	47
Soil Series: COR							
Ahg	0-10	10.000	58	34	23	1.10	58
Aheg	10-18	3.000	55	22	12	1.20	55
Aeg	18-26	3.000	51	18	8	1.30	51
Btg1	26-56	10.000	43	24	12	1.50	43
Btg2	56-83	3.000	43	33	17	1.50	43
BCg	83-100	1.000	43	16	10	1.50	43

Source: J. Tajek, 1992, personal communication.

Note: data are for saturated hydraulic conductivity, (Ksat) volumetric moisture at saturation (KPO), 1/3 bar (KP33) and 15 bar (KP1500), bulk density and total porosity

Site No: 153

Surveyed Location:	Meters South: 285	Meters East: 445	Elev: 722.198
Relative Grid Location:	Row No: 57	Column No: 89	Elev: 722.3

Site Description: Convex, nearly level (0.5%) toe slope to depression at edge of permanently ponded depression. Not sampled or described - too similar to site no. 203.

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm	Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 154

Surveyed Location:	Meters South: 800	Meters East: 0	Elev: N/A
Relative Grid Location:	Row No: 160	Column No: 1	Elev: 726.7

Site Description: Convex, very gently sloping (3%), upper slope to crest position

Site Classification:

Soil Series Classification: Killam (KLM)

Soil Subgroup Classification: Black Solodized Solonetz (BL.SS)

Soil Drainage Classification: Well to moderately well drained

Parent Material Type: Thin veneer of windblown drift overlying till

Parent Material Texture: Silt loam overlying clay loam

Profile Description:

Ap	0-20	loam to clay loam texture; black (10 YR 2/1 m); moderate, medium to fine, granular structure; friable moist, slightly hard dry; abundant, fine to medium, vertical and horizontal, inped and exped roots; clear smooth boundary
Ae	20-25	loam texture; light gray (10 YR 7/2 d); moderate, fine, platy structure; very friable moist, slightly hard dry; few, fine, vertical ,inped and exped roots; abrupt smooth boundary.
Bnt	25-47	clay loam to clay texture; dark grayish brown (10 YR 4/2 m); strong, medium, columnar structure breaking to strong, medium, angular blocky; very firm moist, very hard dry; few to abundant, fine, vertical and horizontal, exped roots; gradual smooth boundary
BCsa	47-68	clay loam texture; dark yellowish brown (10 YR 4/4 m); massive structure; firm moist, sticky plastic wet; very few, fine to medium, ertical, inped roots; common, fine, spherical gypsum concretions throughout matrix; non-effervescent; clear, smooth boundary
Ccasa	68-90	clay loam texture; pinkish gray (7.5 YR 6/2 m); massive structure; firm moist, sticky plastic wet; common, fine, spherical gypsum and lime concretions throughout matrix; moderate effervescence in 10% HCl; moderately calcareous

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	20	5.3	5.0	4.8	0.0	0.8	0.7	12.5	4.2	30.0	0.8	4.1	0.1	1.5	1.1	0.9	30	52	18
Ae	20	25	5.8	5.2	2.6	0.0	2.4	0.3	6.5	4.1	20.1	0.8	7.7	0.1	0.4	0.3	3.1	27	51	22
Bnt	25	47	7.5	7.5	1.0	0.0	9.0	0.7	7.8	11.9	24.2	6.4	71.6	0.3	4.1	10.0	48.3	25	40	35
BCsa	47	68	8.1	8.2	0.0	0.1	11.0	0.5	26.3	10.7	17.5	9.9	111.0	0.6	10.4	19.6	83.5	31	37	32
Ccasa	68	90	8.4	8.4	0.0	7.0	0.0	0.0	0.0	0.0	0.0	8.4	90.7	0.5	10.4	14.5	69.3	26	46	28

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test		BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	20	15	3	1.7	5.8	4.2	3.9	8.7	2	17	3	1.17	1.14	1.17	1.16	56.2	112.4	30.0	60.0
Ae	20	25	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bnt	25	47	40	3	1.2	0.8	0.6	0.8	1.3	23	40	3	1.42	1.50	1.49	1.47	44.5	97.9	42.0	92.4
BCsa	47	68	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Ccasa	68	90	0	0	0.0	0.0	0.0	0.0	0.0	40	90	3	1.59	1.76	1.73	1.69	36.2	79.6	34.0	74.8

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 155

Surveyed Location:	Meters South: 475	Meters East: 290	Elev: 722.790
Relative Grid Location:	Row No: 58	Column No: 95	Elev: 722.9

Site Description: Concave, nearly level (0.5%) centre of temporarily ponded depression. Not sampled or described. Under water at time of sampling and throughout most of the year

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacastrine

Parent Material Texture: Silt loam overlying clay loam to clay

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	20	0	0	0.0	0.0	0.0	0.0	0.0	5	13	1	0.84	0.00	0.00	0.84	68.3	136.6	28.0	56.0
Btg	20	45	0	0	0.0	0.0	0.0	0.0	0.0	35	42	1	1.28	0.00	0.00	1.28	51.7	129.2	31.0	77.5
Cor	45	100	0	0	0.0	0.0	0.0	0.0	0.0	58	64	1	1.78	0.00	0.00	1.78	32.8	180.4	28.0	154.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 175

Surveyed Location:	Meters South: 340	Meters East: 595	Elev: 727.997
Relative Grid Location:	Row No: 68	Column No: 119	Elev: 727.4

Site Description: Convex, very gently sloping (3%) crest position.

Site Classification:

Soil Series Classification: Elnora (EOR)

Soil Subgroup Classification: Orthic Black (O.BL)

Soil Drainage Classification: Well drained

Parent Material Type: Thin veneer of windblown drift overlying till

Parent Material Texture: Loam overlying clay loam

Profile Description:

Ap	0-10	loam to sandy loam texture; black (10 YR 2/1 m); moderate, fine to medium, granular structure; very friable moist and slightly hard dry; abundant, fine to very fine,random, inped and exped roots, abrupt smooth boundary
Bm	10-30	loam to clay loam texture; dark yellowish brown (10 YR 4/4); weak, coarse, prismatic structure breaking to weak, fine, subangular blocky; friable moist and slightly hard dry; plentiful, vertical, inped and exped roots; abrupt smooth boundary
Cca	30-100+	loam to clay loam texture; brown (10 YR 5/3); massive structure; firm moist and hard dry; few, medium to coarse, vertical, inped roots; moderate effervescence in 10% HCl; moderately calcareous; non-saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0 10	5.8	5.0	2.6	0.0	0.2	1.5	12.0	3.8	20.6	0.6	1.1	1.2	1.5	0.9	0.9	50	32	18
Bm	10 30	7.6	7.3	0.8	0.0	0.3	0.3	15.8	6.8	19.5	0.4	1.2	0.1	1.2	0.8	0.5	46	30	24
Cca	30 100	8.3	8.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.5	2.7	0.2	0.9	1.0	1.3	40	40	20

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm	Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0 10	10	3	0.3	0.5	2.1	1.0	1.8	0 8	1	1.31	0.00	0.00	1.31	50.6	50.6	36.0	36.0
Bm	10 30	30	3	2.3	4.7	3.4	3.5	5.3	20 30	1	1.38	0.00	0.00	1.38	47.9	95.8	38.0	76.0
Cca1	30 55	0	0	0.0	0.0	0.0	0.0	0.0	35 45	1	1.26	0.00	0.00	1.26	52.5	131.2	25.0	62.5
Cca2	55 100	0	0	0.0	0.0	0.0	0.0	0.0	55 64	1	1.45	0.00	0.00	1.45	45.3	203.8	28.0	126.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 176

Surveyed Location:	Meters South: 340	Meters East: 555	Elev: 727.052
Relative Grid Location:	Row No: 68	Column No: 111	Elev: 727.0

Site Description: Convex, gently sloping (7%), mid to upper slope position.

Site Classification:

Soil Series Classification: Daysland (DYD)

Soil Subgroup Classification: Block Solod (BL.SO)

Soil Drainage Classification: Well drained

Parent Material Type: Thin veneer of windblown drift and/or slopewash overlying till

Parent Material Texture: loam overlying clay loam

Profile Description:

Ap	0-11	loam texture; black (10 YR 2.5/1 d); moderate, fine to medium, granular structure; very friable moist and slightly hard dry; abundant, fine, vertical and random, inped and exped roots; abrupt smooth boundary
Bntj	11-36	silt loam to silty clay loam texture; dark brown (10 YR 4/3 m); strong, medium, prismatic structure breaking to strong, fine, subangular blocky; friable moist and slightly hard dry; abundant, fine, vertical, inped and exped roots; gradual smooth boundary
BCsa	36-47	loam to clay loam texture; brown (10 YR 5/3 m); weak, coarse, prismatic structure; firm moist and hard dry; few, fine, vertical and horizontal, inped roots; clear smooth boundary
Ccasa	47-100	loam to clay loam texture, brown (10 YR 5/3 m); massive structure; firm moist and hard dry; few ,fine, local concretions of gypsum; weak effervescence in 10% HCl; weakly calcareous, weakly saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	11	5.2	5.0	2.7	0.0	1.2	0.9	8.3	3.9	22.1	1.7	10.2	0.6	2.7	2.3	5.5	40	40	20
Bntj	11	36	7.8	7.7	1.1	0.0	5.1	0.9	11.0	12.5	24.8	2.7	27.7	0.1	1.9	3.2	16.3	12	50	28
BCsa	36	47	8.1	8.1	0.0	0.7	6.1	0.4	28.1	11.9	18.0	6.1	62.9	0.5	10.9	17.2	55.4	39	33	28
Ccasa	47	100	8.4	8.5	0.0	3.7	0.0	0.0	0.0	0.0	0.0	6.5	84.0	0.9	9.7	20.7	70.2	39	34	27

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	11	11	2	0.9	0.8	0.0	0.8	1.8	0	10	1	1.24	0.00	0.00	1.24	53.2	58.5	29.0	31.9
Bntj	11	36	47	3	0.8	0.6	0.7	0.7	0.9	33	43	1	1.35	0.00	0.00	1.35	49.1	122.8	42.0	105.0
BCsa	36	47	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Ccasa	47	100	0	0	0.0	0.0	0.0	0.0	0.0	70	80	1	1.51	0.00	0.00	1.51	43.0	227.9	30.0	159.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 177

Surveyed Location:	Meters South: 340	Meters East: 535	Elev: 725.021
Relative Grid Location:	Row No: 68	Column No: 107	Elev: 724.9

Site Description: Concave, gently sloping (6%), lower slope position.

Site Classification:

Soil Series Classification: Daysland (DYD)

Soil Subgroup Classification: Black Solod (BL.SO)

Soil Drainage Classification: Well to moderately well drained

Parent Material Type: Thin veneer of windblown drift and/or slopewash overlying till

Parent Material Texture: loam overlying clay loam

Profile Description:

Ap	0-13	loam texture; very dark gray (10 YR 3/1.5 d); moderate, fine to medium, granular structure; very friable moist and slightly hard dry; abundant, fine, vertical and random, inped and exped roots; abrupt smooth boundary
Ah	13-17	loam texture; black (10 YR 2/1 m); moderate, fine, granular structure; very friable moist and soft dry; abundant, fine, vertical and horizontal, inped and exped roots; clear wavy boundary
Bm	17-44	loam texture; dark yellowish brown (10 YR 4/4 m); very weak, fine, subangular blocky structure; very friable to friable moist and soft to slightly hard dry; abundant, fine, vertical, inped and exped roots; gradual smooth boundary
Bt	44-62	loam to silt loam texture; brown (10 YR 4/3 m); moderate, medium, prismatic structure breaking to weak, medium, subangular blocky; slightly hard dry and friable moist; few, fine, vertical, inped and exped roots; clear smooth boundary
BCsa	62-85	loam to clay loam texture; brown (10 YR 4/3 m); weak, medium, prismatic structure breaking to weak, medium, subangular blocky; slightly hard dry and friable moist; very few, medium, vertical, inped roots; common, fine, local concentrations of gypsum; no effervescence in 10% HCl; clear smooth boundary
Ccasa	85-100	loam to clay loam texture; light brownish gray (10 YR 6/2 d); massive structure; hard dry and friable to firm moist ; common, fine, local concentrations of gypsum; moderate effervescence in 10% HCl; weakly calcareous; weakly saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	13	5.1	5.0	3.5	0.0	0.3	0.7	11.1	3.4	22.7	2.7	2.8	1.3	6.3	3.5	0.7	46	34	20
Ah	13	17	5.6	5.2	4.2	0.0	0.4	0.3	15.6	3.7	28.5	0.4	1.6	0.0	0.9	0.4	0.7	47	36	17
Bm	17	44	6.0	5.6	0.0	0.0	1.6	0.2	7.5	4.0	16.9	0.7	6.1	0.0	0.4	0.3	2.7	45	36	19
Bt	44	62	6.7	6.5	0.0	0.0	4.7	0.2	7.1	7.3	20.5	2.0	23.4	0.0	1.1	1.2	11.8	33	42	25
BCsa	62	85	7.9	7.9	0.0	1.0	0.0	0.0	0.0	0.0	0.0	6.4	82.7	0.1	10.6	16.9	62.7	40	32	28
Ccasa	85	100	8.1	8.2	0.0	5.4	0.0	0.0	0.0	0.0	0.0	7.1	79.9	0.2	10.8	15.9	64.1	42	30	28

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	13	17	3	7.9	11.5	12.0	10.5	20.8	5	14	1	1.20	0.00	0.00	1.20	54.7	71.1	29.0	37.7
Ah	13	17	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bm	17	44	44	2	0.0	0.0	0.0	0.0	0.1	30	40	1	1.50	0.00	0.00	1.50	43.4	117.2	30.0	81.0
Bt	44	62	62	2	1.4	1.2	0.0	1.3	2.1	40	50	1	1.40	0.00	0.00	1.40	47.2	85.0	30.0	54.0
BCsa	62	85	0	0	0.0	0.0	0.0	0.0	0.0	70	80	1	1.37	0.00	0.00	1.37	48.3	111.1	28.0	64.4
Ccasa	85	100	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 178

Surveyed Location:	Meters South: 340	Meters East: 525	Elev: 724.220
Relative Grid Location:	Row No: 68	Column No: 105	Elev: 724.2

Site Description: Not sampled or described - too close to 177 + 179 and too similar to both.

Site Classification:

Soil Series Classification: Daysland (DYD)

Soil Subgroup Classification: Black Solod (BL.SO)

Soil Drainage Classification: Moderately well drained

Parent Material Type: Thin veneer of recent slope wash overlying till

Parent Material Texture: Silt loam overlying clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm	Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 179

Surveyed Location:	Meters South: 340	Meters East: 515	Elev: 723.907
Relative Grid Location:	Row No: 68	Column No: 103	Elev: 723.8

Site Description: Concave, very gently sloping (3%), lower slope position.

Site Classification:

Soil Series Classification: Killam (KLM) (Clayey subsoil variant)

Soil Subgroup Classification: Black Solodized Solonetz (BL.SS)

Soil Drainage Classification: Moderately well drained

Parent Material Type: Thin veneer of recent slope wash overlying till

Parent Material Texture: Silt loam overlying clay loam to clay

Profile Description:

Ap	0-10	silt loam to loam texture; black (10 YR 2/1 m); strong, fine, granular structure; soft to slightly hard dry and friable moist; abundant, fine to medium, vertical and random, inped and exped roots; clear smooth boundary
Ahe	10-15	silt loam texture; grayish brown (10 YR 5/2 d); moderate, medium, platy structure; slightly hard dry and friable moist, abundant, fine to medium, vertical and horizontal, inped and exped roots; clear smooth boundary
Ahb	15-21	silt loam to loam texture; black (10 YR 2/1 m); strong, coarse, prismatic structure breaking to strong, fine, granular; very friable moist and soft dry; abundant, fine to medium, vertical and oblique, inped and exped roots; clear smooth boundary
Aheb	21-30	silt loam to loam texture; dark grayish brown (10 YR 4/2 m); strong, coarse, prismatic structure breaking to moderate, fine, platy; slightly hard dry and friable moist; abundant, fine to medium, vertical and oblique, inped and exped roots; abrupt, smooth boundary
Bnt	30-49	clay loam texture; dark brown (10 YR 3/3 m); strong, medium to coarse, columnar structure breaking to strong, medium, angular blocky; very hard dry and very sticky, very plastic wet; plentiful, fine to medium, vertical and horizontal, exped roots; weakly saline; clear smooth boundary
BCsa	49-70	clay loam to loam texture; brown (10 YR 4/3); massive structure; very sticky, very plastic wet and firm moist; no roots; common, fine, spherical gypsum concretions throughout matrix; no effervescence in 10% HCl; non-calcareous; moderately saline; abrupt wavy boundary
Ccasag	70-100+	silty clay to clay texture; brown (10 YR 5/3 m); massive structure; very sticky, very plastic wet and firm moist; no roots; common, fine, spherical, gypsum concretions throughout matrix; moderate effervescence in 10% HCl; weakly calcareous; moderately saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	10	4.9	4.4	6.0	0.0	0.8	2.3	10.7	2.5	34.5	0.8	3.9	1.0	0.9	0.5	2.8	34	49	17
Ahe	10	15	4.5	4.3	6.6	0.0	1.4	1.2	11.5	2.7	39.6	1.5	8.0	0.4	2.8	1.4	4.0	28	55	17
Ahb	15	21	4.5	4.4	6.5	0.0	4.0	0.6	8.9	3.1	37.2	3.5	24.8	0.2	5.2	3.6	13.7	34	54	12
Aheb	21	30	5.9	5.7	2.3	0.0	7.8	0.4	5.3	5.4	20.8	6.7	65.5	0.2	2.6	5.9	34.5	35	50	15
Bnt	30	49	7.8	7.8	1.1	0.0	15.0	0.7	5.6	11.2	25.7	6.9	82.3	0.2	1.4	4.8	41.7	23	46	31
BCsa	49	70	8.3	8.2	0.0	0.0	16.0	0.5	27.1	9.4	17.2	11.0	127.0	0.3	9.4	12.7	77.6	33	39	28
Ccasag	70	100	8.6	8.5	0.0	5.5	0.0	0.0	0.0	0.0	0.0	9.9	112.0	0.4	9.3	11.0	69.6	13	43	44

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	10	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Aheb	10	30	30	3	1.2	1.4	1.3	1.3	1.9	10	19	1	0.76	0.00	0.00	0.76	71.3	142.6	24.0	48.0
Bnt	30	49	50	2	0.1	0.1	0.0	0.1	0.1	30	38	1	1.19	0.00	0.00	1.19	55.1	104.7	36.0	68.4
BCsa	49	70	0	0	0.0	0.0	0.0	0.0	0.0	50	60	1	1.38	0.00	0.00	1.38	47.9	100.6	35.0	73.5
Ccasag	70	100	0	0	0.0	0.0	0.0	0.0	0.0	85	95	1	1.80	0.00	0.00	1.80	32.1	96.3	38.0	114.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 180

Surveyed Location:	Meters South: 340	Meters East: 505	Elev: 723.491
Relative Grid Location:	Row No: 68	Column No: 101	Elev: 723.5

Site Description: Concave, nearly level (2%), lower to toe slope position.

Site Classification:

Soil Series Classification: Killam (KLM)

Soil Subgroup Classification: Black Solodized Solonetz (BL.SS)

Soil Drainage Classification: Moderately well drained

Parent Material Type: Thin veneer of recent slope wash overlying till

Parent Material Texture: Silt loam overlying silty clay loam to clay loam

Profile Description:

Ap	0-10	silt loam to loam texture; very dark gray (10 YR 3/1.5 d); moderate, fine, granular structure; very friable moist and soft to slightly hard dry; abundant, fine to medium, vertical and oblique, inped and exped roots; clear smooth boundary
Ahegj	10-20	loam to silt loam texture; dark grayish brown (10 YR 4/2 d); weak, fine, platy to strong, coarse, angular blocky structure; soft to slightly hard dry and very friable moist; few, fine, faint mottles; abrupt smooth boundary
Bnt	20-38	clay loam texture; very dark grayish brown (10 YR 3/2 d); moderate to strong, medium to coarse, columnar structure breaking to strong, medium, angular blocky; very hard dry and very firm moist, abundant, fine, vertical and horizontal, exped roots; moderately saline; gradual, smooth boundary
BCsa	38-60	silty clay loam texture; dark brown (10 YR 4/3 m); massive structure; very sticky, very plastic wet and very firm moist; common, fine, spherical, gypsum concretions throughout matrix; no effervescence in 10% HCl; non-calcareous; moderately saline; clear wavy boundary
Ccasa	60-100+	silty clay loam to clay texture; brown (10 YR 4/3 m); massive structure; very sticky, very plastic wet and very firm moist; no roots; no mottles; common, fine, spherical, gypsum concretions throughout matrix; moderate effervescence in 10% HCl; weakly calcareous; moderately saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	10	5.2	5.0	7.8	0.0	2.5	2.8	17.3	5.7	46.8	1.0	7.1	1.1	0.7	0.6	3.6	33	54	13
Ahegj	10	20	5.3	5.2	2.9	0.0	7.1	0.6	15.8	3.5	17.6	6.3	68.1	0.5	5.0	6.2	41.0	40	47	13
Bnt	20	38	7.7	7.8	1.1	0.0	20.0	0.7	7.1	11.0	23.5	14.0	182.0	0.6	8.9	19.8	113.0	23	47	30
BCsa	38	60	8.1	8.3	0.0	0.2	24.0	0.6	21.9	11.6	21.8	14.0	174.0	0.5	9.3	15.7	104.0	18	46	36
Ccasa	60	100	8.4	8.6	0.0	5.4	0.0	0.0	0.0	0.0	0.0	11.0	128.0	0.4	8.7	10.4	76.8	19	42	39

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	10	0	0	0.0	0.0	0.0	0.0	0.0	5	15	1	1.09	0.00	0.00	1.09	58.9	58.9	28.0	28.0
Ahegj	10	20	20	3	1.1	3.1	4.7	3.0	4.4	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bnt	20	38	38	3	0.3	0.8	0.2	0.4	0.8	28	35	1	1.52	0.00	0.00	1.52	42.6	76.7	31.0	55.8
BCsa	38	60	0	0	0.0	0.0	0.0	0.0	0.0	41	50	1	1.64	0.00	0.00	1.64	38.1	83.8	30.0	66.0
Ccasa	60	100	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 181

Surveyed Location:	Meters South: 340	Meters East: 495	Elev: 723.351
Relative Grid Location:	Row No: 68	Column No: 99	Elev: 723.3

Site Description: Concave, nearly level (2%), toe slope position.

Site Classification:

Soil Series Classification: Killam (KLM) (clayey subsoil variant)

Soil Subgroup Classification: Black Solodized Solonetz (BL.SS)

Soil Drainage Classification: Moderately well to imperfectly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay

Profile Description:

Ah	0-14	silt loam texture; black (10 YR 2.5/1 d); strong, fine, granular structure; very friable moist and soft dry; abundant, fine, vertical and random, inped and exped roots; clear smooth boundary
Ahegj	14-25	silt loam texture; grayish brown (10 YR 5/2 m); weak medium to coarse, platy structure; slightly hard to soft dry and friable moist; abundant, fine, vertical and horizontal, inped and exped roots; common, fine, faint mottles; weakly saline; abrupt wavy boundary
Bnt	25-38	clay to silty clay loam texture; dark grayish brown (10 YR 3.5/2 d); strong, coarse, columnar structure breaking to strong, medium, angular blocky; hard dry and sticky, plastic wet; abundant, fine to coarse, vertical and horizontal, exped roots; moderately saline; gradual smooth boundary
BCsa	38-60	clay to silty clay texture; brown (10 YR 4/3 m); massive structure; very sticky, very plastic wet and very firm moist; common, fine, spherical, gypsum concretions throughout matrix; no effervescence in 10% HCl; non-calcareous; moderately saline; clear smooth boundary
Ccasag	60-100+	heavy clay texture; brown (10 YR 5/3 m); massive structure; very sticky, very plastic wet and very firm moist; few, fine, faint mottles; common, fine, spherical, gypsum concretions throughout matrix; moderate effervescence in 10% HCl; weakly calcareous; moderately saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ah	0	14	5.5	4.9	11.0	0.0	4.4	2.0	14.7	5.8	55.4	0.9	8.0	0.5	0.5	0.4	3.1	26	60	14
Ahegj	14	25	6.5	6.4	5.1	0.0	11.0	0.8	7.6	12.9	37.5	4.5	49.4	0.2	0.8	3.3	24.5	28	56	16
Bnt	25	40	7.7	7.8	1.1	0.0	21.0	0.6	4.8	13.8	29.7	11.0	138.0	0.2	2.1	11.0	74.9	20	38	42
BCsa	40	68	8.2	8.2	0.0	0.2	26.0	0.7	26.4	15.2	28.2	11.0	132.0	0.3	9.4	14.1	83.4	9	37	54
Ccasag	68	100	8.1	8.5	0.0	5.1	0.0	0.0	0.0	0.0	0.0	11.0	131.0	0.3	9.7	14.2	83.1	6	25	69

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	14	0	0	0.0	0.0	0.0	0.0	0.0	5	13	1	1.07	0.00	0.00	1.07	59.6	83.4	27.0	37.8
Ahegj	14	25	25	3	1.0	0.9	1.3	1.1	1.5	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bnt	25	40	40	3	0.0	0.0	0.2	0.1	0.1	20	30	1	1.30	0.00	0.00	1.30	50.9	76.3	39.0	58.5
BCsa	40	68	0	0	0.0	0.0	0.0	0.0	0.0	40	48	1	1.50	0.00	0.00	1.50	43.4	121.5	38.0	106.4
Ccasag	68	100	0	0	0.0	0.0	0.0	0.0	0.0	62	70	1	1.66	0.00	0.00	1.66	37.4	119.7	34.0	108.8

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 182

Surveyed Location: Meters South: 80 Meters East: 715 Elev: 721.291

Relative Grid Location: Row No: N/A Column No: N/A Elev: N/A

Site Description: Not sampled or described. Outside area encompassed by DEM and permanently ponded so no opportunity to sample.

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay to silty clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	24	0	0	0.0	0.0	0.0	0.0	0.0	0	24	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Aeg	24	30	0	0	0.0	0.0	0.0	0.0	0.0	24	30	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Btg	30	68	0	0	0.0	0.0	0.0	0.0	0.0	30	68	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
BCg	68	100	0	0	0.0	0.0	0.0	0.0	0.0	68	100	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 183

Surveyed Location:	Meters South: 100	Meters East: 675	Elev: 722.932
Relative Grid Location:	Row No: 20	Column No: 135	Elev: 722.9

Site Description: Concave; nearly level to depressional (0.5%) at edge of periodically flooded depression. Not sampled or described due to the lack of time and similarity to previously sampled Cordel soils (203, 204, 189).

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay to clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	20	20	3	13.7	15.5	15.8	15.0	23.8	2	10	1	1.25	0.00	0.00	1.25	52.8	105.6	43.0	86.0
Btg	20	38	35	3	0.1	0.2	0.6	0.3	0.4	25	35	1	1.52	0.00	0.00	1.52	42.6	76.7	36.0	64.8
BCg	38	100	0	0	0.0	0.0	0.0	0.0	0.0	60	70	1	1.55	0.00	0.00	1.55	41.5	257.3	34.0	210.8

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 184

Surveyed Location:	Meters South: 180	Meters East: 495	Elev: 721.991
Relative Grid Location:	Row No: 36	Column No: 99	Elev: 721.9

Site Description: Not sampled or described. Site permanently underwater and similar to previously described Cordel soil.

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay to clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	15	0	0	0.0	0.0	0.0	0.0	0.0	0	15	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bg	15	41	0	0	0.0	0.0	0.0	0.0	0.0	15	41	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
BCg	41	100	0	0	0.0	0.0	0.0	0.0	0.0	41	100	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 188

Surveyed Location:	Meters South: 140	Meters East: 575	Elev: 725.096
Relative Grid Location:	Row No: 28	Column No: 115	Elev: 725.0

Site Description: Convex, very gently sloping (3%) upper slope to crest. Not sampled or described - insufficient time to sample.

Site Classification:

Soil Series Classification: Elnora (EOR)

Soil Subgroup Classification: Orthic Black (O.BL)

Soil Drainage Classification: Well drained

Parent Material Type: Thin veneer of windblown drift and/or recent slope wash overlying till

Parent Material Texture: Silt loam overlying clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm	Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
	0 13	12	3	7.9	11.5	16.8	12.1	23.1	0 7	1	1.23	0.00	0.00	1.23	53.6	69.7	36.0	46.8
Btnj	13 36	30	2	0.8	1.3	0.0	1.0	1.8	20 30	1	1.47	0.00	0.00	1.47	44.5	102.3	36.0	82.8
BCsa	36 50	0	0	0.0	0.0	0.0	0.0	0.0	40 50	1	1.33	0.00	0.00	1.33	49.8	69.7	39.0	54.6
Ccasa	50 100	0	0	0.0	0.0	0.0	0.0	0.0	55 65	1	1.50	0.00	0.00	1.50	43.4	217.0	30.0	150.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 189

Surveyed Location:	Meters South: 740	Meters East: 115	Elev: 725.058
Relative Grid Location:	Row No: 148	Column No: 23	Elev: 725.1

Site Description: Concave, nearly level (0.5%), to depressional (<0.5%) at edge of periodically flooded depression. Not sampled or described, under water at time of sampling. Site no. 204 sampled instead as similar soil.

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay to clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	11	0	0	0.0	0.0	0.0	0.0	0.0	3	11	1	0.99	0.00	0.00	0.99	62.6	68.9	37.0	40.7
Aheg	11	20	17	3	0.3	0.3	0.3	0.3	0.6	11	20	1	1.20	0.00	0.00	1.20	54.7	49.2	27.0	24.3
Btg	20	45	40	2	0.1	0.1	0.0	0.1	0.1	25	35	1	1.40	0.00	0.00	1.40	47.2	118.0	34.0	85.0
Ccag	45	100	0	0	0.0	0.0	0.0	0.0	0.0	40	50	1	1.32	0.00	0.00	1.32	50.2	276.1	32.0	176.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 190

Surveyed Location:	Meters South: 600	Meters East: 215	Elev: 727.491
Relative Grid Location:	Row No: 123	Column No: 43	Elev: 727.4

Site Description: Convex, very gently sloping (2%), upper slope to crest position.

Site Classification:

Soil Series Classification: Daysland (DYD)

Soil Subgroup Classification: Black Solod (BL.SO)

Soil Drainage Classification: Well drained

Parent Material Type: Thin veneer of windblown drift and/or recent slope wash overlying till

Parent Material Texture: Silt loam overlying clay loam

Profile Description:

Ap	0-12	loam to silt loam texture; very dark grayish brown (10 YR 3/2 d); moderate to strong, fine to medium, granular structure; slightly hard dry and very friable moist; abundant, fine, to medium, vertical and oblique, inped and exped roots; clear, smooth boundary
Ae	12-22	clay loam to silty clay loam texture; grayish brown (10 YR 5/2 d); moderate, fine, platy structure; slightly hard dry and very friable moist; abundant, fine to medium, vertical and horizontal, inped and exped roots; abrupt smooth boundary
Btnj	22-50	clay to silty clay texture; dark brown (10 YR 3/3 d); weak, medium, prismatic structure breaking to moderate to strong, fine to medium, subangular blocky; hard dry and friable moist; abundant, fine, random, inped and exped roots; no gypsum nodules; gradual smooth boundary
BC	50-64	silty clay to clay texture; brown (10 YR 4/3 d); massive structure; friable to firm moist and slightly hard dry; very few, fine to medium, vertical, inped roots; clear smooth boundary
Ccasa	64-100+	loam to clay loam texture; grayish brown (10 YR 5/2 d); massive structure; firm moist and hard dry; no roots; no mottles; weak effervescence in 10% HCl; weakly calcareous

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	12	5.4	5.0	3.8	0.0	0.4	1.3	14.5	4.3	28.7	0.5	1.6	0.4	0.8	0.5	0.8	31	48	21
Ae	12	22	6.0	5.3	2.0	0.0	1.2	0.4	11.4	5.2	24.5	0.4	3.2	0.0	0.4	0.2	0.9	22	45	33
Btnj	22	50	6.6	6.3	1.1	0.0	3.0	0.6	13.1	9.7	32.4	0.5	5.6	0.0	0.3	0.3	1.8	13	40	47
BC	50	64	7.3	7.2	0.0	0.0	4.8	0.6	12.2	10.9	28.6	1.8	17.7	0.1	1.0	1.1	9.5	10	42	48
Ccasa	64	100	8.0	8.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	6.5	59.2	0.6	11.0	12.9	52.2	39	36	25

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	12	15	3	2.4	2.0	1.7	2.0	4.2	2	12	4	0.99	0.83	1.29	1.10	58.5	70.2	26.0	31.2
Ae	12	22	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Btnj	22	50	40	3	3.1	5.8	5.4	4.8	6.5	30	40	4	1.47	1.42	1.40	1.45	45.3	126.8	30.0	84.0
BC	50	64	70	3	6.1	6.8	5.4	6.1	8.8	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Ccasa	64	100	0	0	0.0	0.0	0.0	0.0	0.0	70	80	4	1.64	1.54	1.64	1.60	39.6	142.6	36.0	129.6

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 191

Surveyed Location:	Meters South: 320	Meters East: 315	Elev: 721.877
Relative Grid Location:	Row No: 64	Column No: 63	Elev: 722.0

Site Description: Concave, nearly level to depressional (1%) toe slope to depressional landscape position at outer margin of permanently flooded depression. Not sampled or described. Covered with water at time of sampling and remained flooded throughout most of the year.

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay to clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	20	0	0	0.0	0.0	0.0	0.0	0.0	5	15	1	1.03	0.00	0.00	1.03	61.1	122.2	37.0	74.0
Btg	20	40	0	0	0.0	0.0	0.0	0.0	0.0	30	40	1	1.55	0.00	0.00	1.55	41.5	83.0	37.0	74.0
Cskg	40	100	0	0	0.0	0.0	0.0	0.0	0.0	53	58	1	2.28	0.00	0.00	2.28	0.0	0.0	24.0	144.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 192

Surveyed Location:	Meters South: 334	Meters East: 275	Elev: 723.027
Relative Grid Location:	Row No: 66	Column No: 55	Elev: 723.1

Site Description: Concave, very gently sloping (3%), lower slope position.

Site Classification:

Soil Series Classification: Foreman (FMN) (variant)

Soil Subgroup Classification: Solonetzic Luvic Gleysol (SZ.LG)

Soil Drainage Classification: Poorly to imperfectly drained

Parent Material Type: Recent lacustrine

Parent Material Texture: Clay

Profile Description:

Ap	0-15	loam to clay loam texture; very dark gray (10 YR 3/1 d); strong, very coarse, blocky structure breaking to moderate, medium to coarse, granular; hard dry, friable to firm moist; very few, fine, random, exped roots; strongly saline; clear smooth boundary
Bngk	15-25	clay to clay loam texture; dark grayish brown (2.5 Y 4/2 m); weak to moderate, fine, subangular blocky structure; sticky plastic, wet and very firm moist; very few, fine, random, exped roots; few, fine, faint mottles; very weak effervescence in 10% HCl; weakly calcareous; strongly saline; gradual wavy boundary
BCsakg	25-44	silty clay to clay texture; very dark grayish brown (2.5 Y 3/2 m); massive structure; very sticky, very plastic wet and very firm moist; common, fine distinct mottles; many, thin, black (10YR2/1) clay films on many voids; common, fine, local concentrations of gypsum; very weak effervescence in 10% HCl; weakly calcareous; strongly saline; clear smooth boundary
Ccasag	44-100+	silty clay to clay texture; light olive brown (2.5 Y 5/4); massive structure; very sticky, very plastic wet and very firm moist; common, fine, distinct mottles; many, fine, irregular, gypsum concretions throughout matrix; moderate effervescence in 10% HCl; weakly calcareous; strongly saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %	
Ap	0	15	5.9	6.0	4.3	0.0	20.0	1.5	10.3	16.3	27.6	17.0	247.0	2.8	10.6	54.6	171.0	34	44	22	
Bngk	15	25	7.8	7.8	0.9	0.0	16.0	1.3	25.6	13.1	23.0	12.0	118.0	1.4	11.2	26.4	112.0	28	31	41	
BCsakg	25	44	8.3	8.4	0.0	1.1	20.0	1.2	46.6	16.1	24.7	13.0	183.0	1.1	10.3	25.3	122.0	17	41	42	
Ccasag	44	120	8.5	8.6	0.0	3.8	0.0	0.0	0.0	0.0	0.0	12.0	144.0	0.9	9.3	17.8	96.8	13	37	50	

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm	Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm	
Ap	0	15	15	3	0.5	1.4	1.1	1.0	2.1	5	12	1	1.64	0.00	0.00	1.64	38.1	57.1	36.0	54.0
Bngk	15	25	25	2	0.1	0.2	0.0	0.2	0.4	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
BCsakg	25	44	0	0	0.0	0.0	0.0	0.0	0.0	25	32	1	2.21	0.00	0.00	2.21	16.6	31.5	36.0	68.4
Ccasag	44	100	0	0	0.0	0.0	0.0	0.0	0.0	50	59	1	1.77	0.00	0.00	1.77	33.2	185.9	30.0	168.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 193

Surveyed Location:	Meters South: 340	Meters East: 175	Elev: 725.273
Relative Grid Location:	Row No: 68	Column No: 35	Elev: 725.3

Site Description: Convex, nearly level (2%), upper slope to crest position.

Site Classification:

Soil Series Classification: Elnora (EOR)

Soil Subgroup Classification: Orthic Black (O.BL)

Soil Drainage Classification: Well drained

Parent Material Type: Thin veneer of windblown drift or recent slope wash overlying till

Parent Material Texture: Loam overlying clay loam

Profile Description:

Ap	0-12	loam texture; black (10 YR 2.5/1 d); moderate to strong, medium, granular structure; slightly hard dry and friable to firm moist; abundant, fine, random, inped and exped roots; clear smooth boundary
Bm1	12-17	loam to clay loam texture; dark yellowish brown (10 YR 4/4 m); very weak, medium, prismatic structure; slightly hard dry and friable moist; abundant, fine to medium, vertical and horizontal, inped roots; clear, wavy boundary
Ahb	17-30	loam to sandy loam texture; very dark gray (10 YR 3/1 m); strong, fine, granular structure; very friable moist and soft to slightly hard dry; abundant, fine to very fine, vertical, inped roots, clear wavy boundary
Bm2	30-47	loam to sandy clay loam texture; brown (10 YR 4/3 m); weak, medium, prismatic structure breaking to moderate, fine, subangular blocky; slightly hard dry and friable moist; plentiful, fine, vertical and horizontal, inped and exped roots; clear wavy boundary
Ccasa	47-100	clay loam texture; grayish brown (10 YR 5/2 m); massive structure; slightly hard to hard dry and friable to firm moist; very few, very fine, vertical, inped roots; moderate effervescence in 10% HCl; weakly calcareous; weakly saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	12	5.3	5.0	2.8	0.0	0.3	0.7	11.0	3.8	21.6	0.7	2.4	0.3	1.3	0.9	1.8	44	39	17
Bm1	12	17	6.7	6.4	1.8	0.0	0.4	0.3	17.6	6.0	23.6	0.6	2.0	0.1	1.5	0.9	1.8	34	43	23
Ahb	17	30	7.2	6.7	2.7	0.0	0.6	0.2	17.7	5.8	22.5	0.4	2.1	0.0	0.8	0.5	1.3	47	39	14
Bm2	30	47	7.8	7.5	0.0	0.0	0.8	0.7	9.5	5.8	14.0	0.7	4.7	0.1	0.9	0.9	1.8	48	31	21
Ccasa	47	100	8.0	8.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	4.3	26.5	0.3	12.4	10.7	34.5	27	39	34

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	test Depth		Num. Test	Field Bulk Density (gm cm -3) BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	12	17	2	12.6	19.7	0.0	16.1	26.8	3	15	1	1.38	0.00	0.00	1.38	47.9	57.5	36.0	43.2
Bm1	12	17	17	1	7.9	0.0	0.0	7.9	19.4	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Ahb	17	30	30	3	19.8	23.0	12.6	18.5	35.5	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bm2	30	47	47	3	19.8	36.0	29.9	28.6	51.6	30	40	1	1.51	0.00	0.00	1.51	43.0	73.1	40.0	68.0
Ccasa	47	100	0	0	0.0	0.0	0.0	0.0	0.0	65	75	1	1.49	0.00	0.00	1.49	43.8	232.1	30.0	159.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 194

Surveyed Location:	Meters South: 420	Meters East: 95	Elev: 722.676
Relative Grid Location:	Row No: 84	Column No: 19	Elev: 722.8

Site Description: Concave, level to depressional (0.5%), centre of permanently ponded depression. Not described or sampled. Flooded by water at time of sampling and throughout most of the year.

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay to clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	test Depth	Num. Test	Field Bulk Density (gm cm -3) BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm	
Ah	0	18	0	0	0.0	0.0	0.0	0.0	0.0	0	18	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Btg	18	45	0	0	0.0	0.0	0.0	0.0	0.0	18	45	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
BCg	45	100	0	0	0.0	0.0	0.0	0.0	0.0	45	100	1	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 200

Surveyed Location:	Meters South: 340	Meters East: 460	Elev: 723.098
Relative Grid Location:	Row No: 68	Column No: 92	Elev: 723.3

Site Description: Concave, nearly level (2%), toe slope position within fringe of willow surrounding large permanently flooded depression.

Site Classification:

Soil Series Classification: Killam-gleyed phase (KLM/g)

Soil Subgroup Classification: Gleyed Black Solodized Solonetz (GLBL.SS)

Soil Drainage Classification: Moderately well to imperfectly drained

Parent Material Type: Thin veneer of recent slope wash overlying till

Parent Material Texture: Silt loam overlying clay loam

Profile Description:

Ah	0-10	silt loam texture; black (10 YR 2.5/1 m); strong, fine to medium, granular structure; friable moist and soft to slightly hard dry; abundant, fine to medium, horizontal and random, inped and exped roots; gradual smooth boundary
Aheg	10-16	silt loam to loam texture; grayish brown (10 YR 5/2 m); weak, medium, platy to weak, medium, angular blocky structure; slightly hard dry and friable moist, abundant, fine to medium, vertical and horizontal, inped and exped roots; few, fine, distinct mottles; abrupt wavy boundary
Bnt	16-27	loam to silt loam texture; dark grayish brown (10 YR 4/2 m); moderate, fine to medium, columnar structure breaking to strong, fine to medium, angular blocky; hard dry and firm moist, plentiful, fine to medium, vertical and random, exped roots; weakly saline; gradual smooth boundary
Bntsa	27-44	silty clay to silty clay loam texture; brown (10 YR 4/3 m); strong, fine, subangular blocky structure; firm moist and hard dry, few, medium, vertical, inped and exped roots; no mottles; no effervescence in 10% HCl; common, fine, spherical gypsum concretions throughout matrix; moderately saline; clear smooth boundary
BCgsa	44-60	silty clay to silty clay loam texture; dark grayish brown (2.5 Y 4/2); massive structure; sticky plastic wet and firm moist; common, fine, faint, mottles; many, medium, spherical gypsum concretions throughout matrix; no effervescence in 10% HCl; moderately saline; clear wavy boundary
Ccasag	60-100	clay loam texture; grayish brown (2.5 Y 5/2); massive structure; very firm moist and sticky plastic wet; common, fine, faint mottles; common, fine, spherical gypsum concretions throughout matrix; moderate effervescence in 10% HCl; weakly calcareous; moderately saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1				Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1					Particle Size		
							Na	K	Ca	Mg			Na	K	Ca	Mg	SO4	Sand %	Silt %	Clay %
Ah	0	10	6.9	6.4	13.0	0.0	3.3	5.7	34.4	14.3	58.4	0.9	5.8	2.6	0.8	0.8	2.2	36	56	8
Aheg	10	16	7.6	7.2	4.8	0.0	4.1	3.6	14.8	6.8	27.9	1.5	15.1	2.2	1.4	0.9	3.3	31	52	17
Bnt	16	27	8.1	7.9	1.8	0.0	6.9	3.1	10.9	5.8	24.1	4.4	48.6	2.3	2.3	2.2	23.2	27	47	26
Bntsa	27	44	8.2	8.3	0.0	0.1	18.0	3.8	13.4	11.3	33.5	9.0	107.0	2.6	5.0	7.5	60.8	13	46	41
BCgsa	44	60	8.1	8.2	0.0	0.1	18.0	2.6	18.5	10.8	27.5	10.0	115.0	2.5	9.7	10.2	72.6	10	47	43
Ccasag	60	120	8.4	8.3	0.0	3.5	0.0	0.0	0.0	0.0	0.0	8.5	94.0	2.1	9.9	8.3	61.3	37	32	31

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr							Field Bulk Density (gm cm -3)						TP %	TP mm	Est. FP %	Est. FP mm
			test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	test Depth	Num. Test	BD1	BD2	BD3	Ave. BD				
Ah	0	10	0	0	0.0	0.0	0.0	0.0	0.0	5	12	1	1.15	0.00	0.00	1.15	56.6	56.6	29.0	29.0
Aheg	10	16	15	3	0.5	0.5	0.7	0.6	1.2	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bnt	16	27	0	0	0.0	0.0	0.0	0.0	0.0	20	30	1	1.23	0.00	0.00	1.23	53.6	59.0	37.0	40.7
Bntsa	27	44	43	3	0.3	0.4	0.6	0.5	0.7	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
BCgsa	44	60	0	0	0.0	0.0	0.0	0.0	0.0	40	50	1	1.56	0.00	0.00	1.56	41.1	65.8	33.0	52.8
Ccasag	60	100	0	0	0.0	0.0	0.0	0.0	0.0	60	70	1	1.57	0.00	0.00	1.57	40.8	163.2	33.0	132.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 201

Surveyed Location:	Meters South: 340	Meters East: 455	Elev: 723.118
Relative Grid Location:	Row No: 68	Column No: 91	Elev: 723.2

Site Description: Concave, nearly level (1%), toe slope at edge of ponded depression.

Site Classification:

Soil Series Classification: Foreman (FMN) (variant)

Soil Subgroup Classification: Solonetzic Luvic Gleysol (SZ.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay

Profile Description:

Ah	0-10	silt loam texture; black (10 YR 2.5/1 m); moderate, fine, granular structure; friable moist and soft to slightly hard dry; abundant, fine to medium, vertical and random, inped and exped roots; no mottles; clear smooth boundary
Ahe	10-12	loam to silt loam texture; grayish brown (10 YR 5/2 d); moderate, fine, platy structure; slightly hard dry and friable moist; abundant, fine to medium, horizontal and vertical, inped and exped roots; no mottles; abrupt wavy boundary
Bn	12-24	loam texture; very dark grayish brown (10 YR 3/2 d); moderate, medium, columnar structure breaking to strong, medium, angular blocky; very hard dry and very firm moist; abundant, fine, vertical, exped roots; no mottles; gradual smooth boundary
Bnt	24-35	clay to clay loam texture; brown (10 YR 4/3 d); strong, medium, angular blocky structure; firm moist and hard dry, few, fine to medium, vertical, inped and exped roots; no mottles; abrupt smooth boundary
Ccasag	35-100	clay loam to clay texture; dark grayish brown (2.5 Y 4/2 m); pseudo-blocky structure; very sticky, very plastic wet and firm moist; few, medium to coarse, vertical, inped roots; common, fine, distinct mottles; many, medium, spherical gypsum concretions throughout matrix; weak effervescence in 10% HCl; weakly calcareous; weakly saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ah	0	10	6.7	6.1	9.3	0.0	3.2	3.6	22.4	8.8	44.2	0.7	6.0	1.2	0.5	0.4	1.4	35	56	9
Ahe	10	12	7.4	7.0	5.0	0.0	5.7	3.5	15.4	6.9	30.7	1.6	17.0	1.5	1.1	0.8	4.0	35	47	18
Bn	12	24	7.6	7.6	3.5	0.0	8.0	4.1	15.8	8.0	35.3	1.6	19.7	1.3	1.1	0.7	5.2	34	45	21
Bnt	24	35	8.3	8.4	1.5	0.1	11.0	3.1	12.6	7.1	27.7	3.8	47.3	1.3	1.2	1.2	20.9	27	42	31
Ccasag	35	50	8.3	8.4	0.0	3.3	0.0	0.0	0.0	0.0	0.0	5.7	64.4	0.8	4.6	2.6	36.4	24	37	39

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	10	13	3	0.1	0.1	0.5	0.3	0.5	5	12	1	1.14	0.00	0.00	1.14	57.0	57.0	42.0	42.0
Ahe	10	12	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bn	12	24	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bnt	24	35	33	2	0.2	0.5	0.0	0.4	0.5	20	30	1	1.18	0.00	0.00	1.18	55.5	61.0	39.0	42.9
Ccasag	35	100	0	0	0.0	0.0	0.0	0.0	0.0	80	88	2	1.84	1.67	0.00	1.75	34.0	221.0	39.0	253.5

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 202

Surveyed Location:	Meters South: 341	Meters East: 440	Elev: 722.683
Relative Grid Location:	Row No: 62	Column No: 87	Elev: 722.8

Site Description: Concave, nearly level (1%), toe slope in willow ring at edge of ponded depression.

Site Classification:

Soil Series Classification: Foreman (FMN) (variant)

Soil Subgroup Classification: Solonetzic Luvic Gleysol (SZ.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay to clay loam

Profile Description:

Ah	0-11	silt loam to loam texture; very dark gray (10 YR 3/1.5 d); moderate, medium, granular structure; friable to firm moist and slightly sticky, slightly plastic wet; abundant, fine, vertical, inped and exped roots; no mottles; clear smooth boundary
Aheg	11-13	loam texture; dark grayish brown (10 YR 4/2 d); weak, coarse, platy structure; slightly hard dry and friable to firm moist; plentiful, fine to medium, vertical, inped and exped roots; common, medium, distinct mottles; abrupt smooth boundary
Bntg1	13-20	clay loam texture; dark brown (10 YR 3/3 d); strong, coarse, columnar structure breaking to moderate, coarse, blocky; very hard dry and very sticky, very plastic wet; few, fine, vertical, exped roots; many, coarse, distinct mottles; gradual smooth boundary
Bntg2	20-40	clay to clay loam texture; very dark grayish brown (2.5 Y 3/2 m); moderate to strong, medium, angular blocky structure; very sticky, very plastic wet and very firm moist; few, fine, vertical, exped roots; many , medium to coarse, prominent mottles; clear smooth boundary
Ccasag	40-100	clay loam texture; dark grayish brown (2.5 Y 4/2 m); moderate, coarse, pseudo-platy structure; sticky plastic wet and firm moist; no roots; common, medium, distinct mottles; moderate effervescence in 10% HCl; moderately calcareous

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L-1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ah	0	11	6.5	6.0	15.0	0.0	1.9	2.5	38.6	12.1	60.1	0.8	4.8	1.6	1.5	1.2	1.4	42	51	7
Aheg	11	13	6.9	6.4	3.6	0.0	1.6	1.1	14.6	6.4	25.0	0.6	5.7	0.4	0.7	0.5	1.0	39	42	19
Bntg1	13	20	7.0	6.8	1.7	0.0	2.8	1.4	13.0	9.3	27.4	0.8	7.6	0.3	0.5	0.4	2.3	33	34	33
Bntg2	20	40	7.6	7.5	0.0	0.0	4.0	1.7	15.3	12.5	33.5	1.0	8.8	0.3	0.5	0.5	3.0	28	31	41
Ccasag	40	100	8.2	8.2	0.0	7.0	0.0	0.0	0.0	0.0	0.0	2.2	20.0	0.5	1.4	1.9	11.5	36	31	33

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test		BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ah	0	11	13	2	6.1	13.7	0.0	9.9	18.4	0	10	1	1.01	0.00	0.00	1.01	61.9	68.1	42.0	46.2
Aheg	11	13	13	1	0.4	0.0	0.0	0.4	1.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bntg1	13	20	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bntg2	20	40	40	2	2.3	0.9	0.0	1.6	2.2	20	30	1	1.47	0.00	0.00	1.47	44.5	89.0	40.0	80.0
Ccasag	40	100	0	0	0.0	0.0	0.0	0.0	0.0	50	60	2	1.56	1.70	0.00	1.63	38.5	231.0	36.0	216.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 203

Surveyed Location:	Meters South: 314	Meters East: 435	Elev: 722.088
Relative Grid Location:	Row No: 62	Column No: 87	Elev: 722.1

Site Description: Concave, level to depressional (0.5%), site at edge of permanently flooded depression.

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Loam overlying clay loam

Profile Description:

Ap	0-18	loam texture; black (10 YR 2/1 m); strong, fine, granular structure; friable moist and slightly sticky, slightly plastic wet; abundant, fine to medium, vertical and random, inped and exped roots; no mottles; clear smooth boundary
Aeg	18-23	sandy loam to sandy clay loam texture; grayish brown (10 YR 5/2 m); moderate to strong, fine to medium, platy structure; friable moist and slightly sticky, slightly plastic wet; few, fine to medium, inped roots; common, medium to coarse, distinct mottles; gradual smooth boundary
Btg	33-50	clay loam texture; dark brown (7.5 YR 4/4 m); weak to moderate, medium, subangular blocky structure; very sticky, very plastic wet and very firm moist; few, fine to medium, vertical, inped roots; many, medium to coarse, distinct mottles, gradual smooth boundary
BCg	50-100+	clay loam to loam texture; grayish brown (2.5 Y 5/2 m); massive structure; very sticky, very plastic wet and very firm moist; common, medium, distinct mottles; no effervescence in 10% HCl; non-calcareous; non-saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1				Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1					Particle Size		
							Na	K	Ca	Mg			Na	K	Ca	Mg	SO4	Sand %	Silt %	Clay %
Ap	0	18	5.6	5.2	4.9	0.0	1.2	1.6	11.8	3.6	22.2	1.2	7.2	1.5	1.8	1.2	4.9	51	39	10
Aeg	18	33	6.2	6.0	0.8	0.0	0.9	0.7	4.8	1.9	7.6	1.8	12.6	1.4	2.8	2.0	10.5	60	29	11
Btg	33	50	5.7	5.6	0.7	0.0	2.0	1.4	11.3	5.8	22.2	2.1	14.0	1.5	3.6	2.4	12.7	35	30	35
BCg	50	120	7.1	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	6.4	0.7	1.6	0.8	4.1	40	32	28

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr							Field Bulk Density (gm cm -3)							TP %	TP mm	Est. FP %	Est. FP mm
			test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	test Depth		Num. Test	BD1	BD2	BD3	Ave. BD				
Ah	0	18	16	3	0.1	0.1	0.6	0.2	0.3	5	12	1	1.30	0.00	0.00	1.30	50.9	91.6	44.0	79.2
Aeg	18	33	32	2	0.0	0.1	0.0	0.0	0.1	20	28	1	1.74	0.00	0.00	1.74	34.3	51.5	31.0	46.5
Btg	33	50	0	0	0.0	0.0	0.0	0.0	0.0	35	45	1	1.42	0.00	0.00	1.42	46.4	78.9	34.0	57.8
BCg	50	100	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 204

Surveyed Location:	Meters South: 715	Meters East: 140	Elev: 725.472
Relative Grid Location:	Row No: 143	Column No: 28	Elev: 725.4

Site Description: Concave, gently sloping (3%), toe slope at edge of temporarily ponded depression. (Recently cleared of willow and poplar).

Site Classification:

Soil Series Classification: Cordel (COR)

Soil Subgroup Classification: Humic Luvic Gleysol (HU.LG)

Soil Drainage Classification: Poorly drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Silt loam overlying clay

Profile Description:

Ap	0-16	loam to silt loam texture; very dark gray (10 YR 3/1.5 d); moderate, coarse, granular structure; slightly hard dry and friable moist; plentiful, medium to coarse, horizontal and vertical, inped and exped roots; common, medium, irregular nodules of Ae horizon material in local concentrations; abrupt smooth boundary
Ae	16-30	loam to silt loam texture; grayish brown (10 YR 5/2 m); strong, coarse, platy structure; slightly hard to hard dry and friable moist; very few, coarse, horizontal, exped roots; few, fine, faint mottles; clear smooth boundary
Btg	30-60	clay to clay loam texture; dark yellowish brown (10 YR 4/4 m); weak, fine, subangular blocky structure; very firm moist and hard dry; abundant, medium, distinct mottles; no roots; diffuse smooth boundary
BCg	60-100+	clay texture; dark grayish brown (2.5 Y 4/2 m); massive structure; sticky plastic wet and very firm moist; no roots; many, medium, distinct mottles; no effervescence in 10% HCl; no salts

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1				Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1					Particle Size		
							Na	K	Ca	Mg			Na	K	Ca	Mg	SO4	Sand %	Silt %	Clay %
Ap	0	16	5.7	5.2	6.8	0.0	0.1	3.1	15.7	2.7	31.8	0.4	0.4	1.7	0.6	0.3	0.6	28	57	15
Ae	16	30	6.1	5.3	0.5	0.0	0.1	1.0	3.3	1.0	6.5	0.3	0.7	1.0	0.8	0.4	0.9	30	55	15
Btg	30	60	5.8	5.6	0.6	0.0	0.1	1.6	11.8	5.4	23.5	0.2	0.3	0.5	0.3	0.2	0.4	24	37	39
BCg	60	100	5.8	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.6	0.5	0.2	0.7	17	38	45

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr							Field Bulk Density (gm cm -3)							TP %	TP mm	Est. FP %	Est. FP mm
			test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	test Depth		Num. Test	BD1	BD2	BD3	Ave. BD				
Ap	0	16	13	3	1.6	1.6	4.7	2.6	5.0	7	14	5	0.89	1.07	0.93	0.95	64.2	102.7	32.0	51.2
Ae	16	30	0	0	0.0	0.0	0.0	0.0	0.0	21	28	1	1.87	0.00	0.00	1.87	29.4	41.2	28.0	39.2
Btg	30	60	40	3	0.2	0.4	0.4	0.3	0.5	48	58	4	1.64	1.62	1.49	1.57	40.8	122.4	38.0	114.0
BCg	60	100	0	0	0.0	0.0	0.0	0.0	0.0	60	70	6	1.64	1.54	1.84	1.69	36.2	144.8	34.0	136.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 205

Surveyed Location:	Meters South: 685	Meters East: 170	Elev: 726.742
Relative Grid Location:	Row No: 137	Column No: 34	Elev: 726.7

Site Description: Convex, very gently sloping (3%), mid to lower slope position at edge of cultivated fringe surrounding temporarily ponded depression.

Site Classification:

Soil Series Classification: Killam (KLM) (clayey Variant)

Soil Subgroup Classification: Black Solodized Solonetz (BL.SS)

Soil Drainage Classification: Moderately well drained

Parent Material Type: Thin veneer of recent slope wash overlying recent lacustrine

Parent Material Texture: Loam overlying heavy clay

Profile Description:

Ap	0-13	loam to silt loam texture; very dark gray (10 YR 3/1.5 d); moderate, fine, granular structure; friable moist and slightly hard dry; abundant, fine to medium, vertical to oblique, inped and exped roots; clear, smooth boundary
Ae	13-20	loam texture; grayish brown (10 YR 5/2 d); moderate, fine, platy structure; friable moist and slightly hard dry; very few, fine, vertical and oblique, inped and exped roots; abrupt smooth boundary
Bnt	20-50	clay loam to clay texture; dark brown (10 YR 3/3 d); moderate to strong, medium to coarse, columnar structure breaking to strong medium angular blocky; hard dry and very firm moist; plentiful, fine, vertical, exped roots; gradual wavy boundary
Bntsa	50-60	heavy clay to clay texture; dark brown (10 YR 4/3 d); moderate to strong, fine to medium, angular blocky structure; very firm moist and hard dry; very few, fine, vertical and oblique, exped roots; common, fine, irregular gypsum concretions throughout matrix; no visible effervescence in 10% HCl; clear smooth boundary
Ccasa	60-100+	heavy clay texture; light brownish gray (10 YR 6/2 d); massive structure; very firm moist and hard dry; common, fine, irregular gypsum concretions throughout matrix; weak effervescence in 10% HCl; weakly calcareous; weakly saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	13	5.5	5.2	8.1	0.0	0.5	4.4	14.5	5.8	38.2	0.9	2.2	4.2	1.2	1.0	2.3	34	50	16
Ae	13	20	5.8	5.4	1.1	0.0	0.4	1.6	4.2	2.6	11.5	1.0	4.4	2.8	1.1	1.3	2.3	38	47	15
Bnt	20	50	7.0	6.7	0.7	0.0	1.3	1.0	5.5	14.7	24.5	0.7	5.5	0.3	0.5	1.4	2.2	36	32	32
Bntsa	50	60	7.9	7.6	0.0	0.9	3.4	0.8	32.7	20.1	33.2	4.7	23.2	0.6	12.0	16.8	36.7	6	23	71
Ccasa	60	100	8.2	8.2	0.0	3.7	0.0	0.0	0.0	0.0	0.0	6.5	42.7	0.6	10.8	25.0	53.5	4	16	80

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	test Depth	Num. Test	Field Bulk Density (gm cm -3) BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	13	15	3	4.3	1.5	6.8	4.2	7.0	0	10	4	0.82	0.95	1.01	0.97	63.4	82.4	30.0	39.0
Ae	13	20	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bnt	20	50	40	3	0.4	0.4	0.3	0.4	0.6	22	32	4	1.49	1.54	1.25	1.46	44.9	134.7	42.0	126.0
Bntsa	50	60	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Ccasa	60	100	70	3	9.4	12.6	13.3	11.8	16.6	60	70	4	1.40	1.23	1.44	1.38	47.9	191.6	29.0	116.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 207

Surveyed Location:	Meters South: 180	Meters East: 595	Elev: N/A
Relative Grid Location:	Row No: 36	Column No: 119	Elev: 725.3

Site Description: Concave, nearly level (2%), lower slope position in minor swale in raised, upland portion of the landscape.

Site Classification:

Soil Series Classification: Elnora (EOR)

Soil Subgroup Classification: Orthic Black (O.BL)

Soil Drainage Classification: Well drained

Parent Material Type: Thin veneer of windblown drift and/or recent slope wash overlying till

Parent Material Texture: Loam overlying clay loam

Profile Description:

Ap	0-14	loam to silt loam texture; very dark gray (10 YR 3/1.5 d); moderate, fine to medium, granular structure; very friable moist and slightly hard dry; abundant, very fine to fine, random, inped and exped roots; clear smooth boundary
Btj	14-44	clay loam texture; dark yellowish brown (10 YR 4/4 d); moderate, coarse, prismatic structure breaking to weak to moderate, fine, subangular blocky; friable moist and slightly hard dry; abundant, fine, vertical, inped and exped roots; clear smooth boundary
Bm	44-84	loam to clay loam texture; dark brown (10 YR 3/3 d); moderate to strong, coarse, prismatic structure breaking to weak,medium, subangular blocky; firm moist and hard dry; few to plentiful, vertical, exped roots; no effervescence in 10% HCl; abrupt smooth boundary
Cca	84-100+	loam to clay loam texture; light brownish gray (10 YR 6/2 d); massive structure, hard dry and firm moist; weak effervescence in 10% HCl; weakly calcareous

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1				Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1					Particle Size		
							Na	K	Ca	Mg			Na	K	Ca	Mg	SO4	Sand %	Silt %	Clay %
Ap	0	14	4.7	4.5	4.6	0.0	0.3	1.3	9.6	2.6	29.7	1.7	2.4	1.4	3.5	2.0	0.8	35	46	19
Btj	14	44	5.7	5.5	0.9	0.0	0.2	0.5	13.4	6.1	23.9	0.7	0.6	0.1	0.4	0.3	0.4	37	32	31
Bm	44	89	6.4	5.9	0.5	0.0	0.3	0.4	12.3	5.0	18.5	0.7	1.8	0.2	2.0	1.0	3.6	41	33	26
Cca	89	100	7.8	7.7	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.2	6.2	0.2	3.1	1.5	6.7	44	30	26

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr							Field Bulk Density (gm cm -3)						TP %	TP mm	Est. FP %	Est. FP mm
			test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	test Depth		Num. Test	BD1	BD2	BD3	Ave. BD			
Ap	0	14	14	3	4.0	4.7	6.6	5.1	9.1	2	10	1	1.29	0.00	0.00	1.29	51.3	71.8	36.0	50.4
Btj	14	44	39	3	9.4	15.8	10.4	11.9	17.0	25	35	1	1.49	0.00	0.00	1.49	43.8	131.4	41.0	123.0
Bm	44	84	60	3	28.1	19.4	11.5	19.7	34.7	52	57	1	1.85	0.00	0.00	1.85	30.2	120.8	38.0	152.0
Cca	84	100	0	0	0.0	0.0	0.0	0.0	0.0	79	88	1	1.68	0.00	0.00	1.68	36.6	58.6	32.0	51.2

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 211

Surveyed Location:	Meters South: 340	Meters East: 255	Elev: N/A
Relative Grid Location:	Row No: 68	Column No: 51	Elev: 723.9

Site Description: Convex, very gently sloping (3%), mid to lower slope position.

Site Classification:

Soil Series Classification: Daysland (DYD)

Soil Subgroup Classification: Black Solod (BL.SO)

Soil Drainage Classification: Moderately well drained

Parent Material Type: Thin veneer of recent slope wash overlying till

Parent Material Texture: Loam overlying clay loam

Profile Description:

Ap	0-15	loam texture; very dark gray (10 YR 3/1 d); moderate, fine to medium, granular structure; slightly hard dry and friable moist; few to abundant, fine, vertical and random, inped and exped roots; abrupt smooth boundary
Ae	15-17	loam to very fine sandy loam texture; dark grayish brown (10 YR 4/2 d); weak, fine, platy structure; soft to slightly hard dry and very friable moist; few, fine, vertical and horizontal, inped and exped roots; abrupt wavy boundary
Bntj	17-50	clay loam texture; dark brown (10 YR 3/3 d); moderate, medium, columnar structure breaking to strong, fine to medium, subangular blocky; hard to slightly hard dry and firm moist; abundant, fine, vertical and horizontal, exped roots; gradual wavy boundary
BCsa	50-72	silty clay loam to silty clay texture; dark brown (10 YR 4/3 d); massive structure to very weak, medium prismatic; friable to firm moist and slightly hard dry; few, very fine, vertical, exped roots; common, fine, spherical gypsum concretions throughout matrix, no effervescence in 10% HCl; moderately saline; gradual wavy boundary
Ccasa	72-100+	clay loam to silty clay loam texture; grayish brown (2.5 Y 5/2); massive structure; friable moist and slightly hard dry; common, fine, spherical gypsum concretions throughout matrix; moderate effervescence in 10% HCl; weakly calcareous; moderately saline

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm		pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %
Ap	0	15	4.8	4.3	3.7	0.0	0.9	1.2	5.7	2.0	23.1	0.9	6.1	0.6	1.0	0.7	2.0	45	40	15
Ae	15	17	5.3	4.9	1.3	0.0	1.1	0.3	5.0	2.1	13.2	1.0	8.2	0.1	0.9	0.7	2.6	47	39	14
Bntj	17	50	6.8	6.6	0.8	0.0	4.7	0.4	12.6	7.9	28.6	1.3	14.9	0.0	0.7	0.6	7.4	28	37	35
BCsa	50	72	8.0	8.0	0.0	0.1	14.0	0.4	23.0	12.7	25.7	8.8	96.6	0.1	10.1	12.8	68.2	15	45	40
Ccasa	72	100	8.2	8.3	0.0	4.5	0.0	0.0	0.0	0.0	0.0	8.5	94.7	0.1	10.2	11.7	65.4	21	46	33

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth	Num. Test		BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	15	17	2	22.0	6.8	0.0	14.4	22.3	0	8	1	1.00	0.00	0.00	1.00	62.3	93.5	29.0	43.5
Ae	15	17	17	1	1.0	0.0	0.0	1.0	2.3	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
Bntj1	17	33	33	2	0.1	0.1	0.0	0.1	0.2	30	37	1	1.51	0.00	0.00	1.51	43.0	68.8	21.0	33.6
Bntj2	33	50	50	2	0.1	0.0	0.0	0.0	0.1	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0
BCsa	50	72	0	0	0.0	0.0	0.0	0.0	0.0	55	65	1	1.69	0.00	0.00	1.69	36.2	79.6	35.0	77.0
Ccasa	72	100	0	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

Site No: 300

Surveyed Location:	Meters South: 120	Meters East: 625	Elev: N/A
Relative Grid Location:	Row No: 24	Column No: 125	Elev: 723.4

Site Description: Convex, very gently sloping (3%), mid to lower slope position.

Site Classification:

Soil Series Classification: Daysland (DYD)

Soil Subgroup Classification: Black Solod (BL.SO)

Soil Drainage Classification: Moderately well drained

Parent Material Type: Thin veneer of windblown drift and/or recent slope wash overlying till

Parent Material Texture: Silt loam over clay loam

Profile Description:

Laboratory Analysis of Selected Horizons:

Horizon type	Horizon depth cm	pH H2O	pH CaCl2	Total carbon %	CaCO3 equiv %	Exchangeble Cations cmol (+) Kg - 1 Na	K	Ca	Mg	Total Exch Cation	E.C. dSm-1	Soluble Cations and Anions mmol L -1 Na	K	Ca	Mg	SO4	Particle Size Sand %	Silt %	Clay %

Field Analysis of Physical and Hydrological Properties:

Horizon type	Horizon depth cm		Saturated Hydraulic Conductivity mm/hr test depth	Num. tests	K1	K2	K3	Ave Ksat	Max Ksat	Field Bulk Density (gm cm -3) test Depth		Num. Test	BD1	BD2	BD3	Ave. BD	TP %	TP mm	Est. FP %	Est. FP mm
Ap	0	14	15	3	4.0	11.5	20.4	12.0	18.6	3	10	1	1.38	0.00	0.00	1.38	47.9	67.1	30.0	42.0
Bnt	14	42	40	1	15.5	0.0	0.0	15.5	24.1	27	37	1	1.59	0.00	0.00	1.59	40.0	112.0	31.0	86.8
Ccasag	42	100	0	0	0.0	0.0	0.0	0.0	0.0	60	69	1	1.77	0.00	0.00	1.77	33.2	192.6	30.0	174.0

E.C. - electrical conductivity (dS m -1); BD - bulk density (g cm -3); TP - total porosity (% and mm); FP - est field capacity (% and mm).
Ksat - saturated hydraulic conductivity (mm/hr.) Guelph constant head permeameter method (Elrick et al, 1989).
Max Ksat - maximum likely saturated hydraulic conductivity (mm/hr.) (see Elrick, et al, 1989). * Suspect value - out of normal range, disregard

APPENDIX 4

SOIL MOISTURE MONITORING DATA

RECORDED AT THE LUNTY SITE

A4.1 Introduction

This appendix contains all data on soil moisture and soil tension collected from the instrumented sites. The original TDR and gypsum block data collected at each of the three depth intervals (0-15, 15-40 and 40-60 cm) are listed by site number and date in Table A4.1. The column labelled Raw TDR is the original TDR reading. The column labelled TDR(θ) contains the computed volumetric moisture content. This value incorporates the correction equation suggested by Topp and Culley (1989). TDR(θ) data for the depths 15-40 and 40-60 cm were computed by differencing as described by Topp (1987). The column labelled Raw Gyp reports the original field reading taken from the gypsum block. The column labelled Gyp(h) contains the value for head estimated for each gypsum block reading using graphs supplied by the manufacturer (Soilmoisture Equipment Corp).

Graphs of the change in volumetric soil moisture (TDR(θ)) through time are presented by Soil Series by depth to illustrate the variation in observed soil moisture (Figures A4.1 through A4.5). The graphs provide a visual tool for analysing the data to identify patterns of change in soil moisture through time for each Series and depth. The graphs help to highlight the extreme variability and suspect nature of some of the data. They also provide a convenient means of identifying maximum and minimum values for moisture content for each horizon of each major soil type.

The original data are reformatted and resorted as Table A4.2 in order to facilitate an evaluation of the degree of correspondence between estimates produced by TDR and matching estimates produced by gravimatric sampling at specific dates. There is poor correspondence between estimates produced by TDR and those produced by gravimetric sampling, especially for the lower (B and C) horizons. Considerable method error is evident in the TDR data, especially for lower horizons of wet or saturated soils. TDR error is ascribed to both the diffferencing method of calculating moisture content over the interval of interest and to instrument error in detecting the return of the TDR pulse over longer intervals (0-60 cm) in wet soils. Estimates based on gravimetric sampling are generally more credible but also contain error related to the selection of a value of bulk density (BD) to use to convert from gravimetric to volumetric moisture content. A single, best estimate, of bulk density for each soil and depth was used to convert from gravimetric to volumetric moisture content. The bulk density of some horizons (especially surface horizons) clearly changed throughout the period of monitoring, so a single value for bulk density for each soil and depth is bound to be in error for some time periods.

Differences in the entity sampled by each of the two methods are a final contributor to the differences observed in volumetric moisture content as determined gravimetrically and by TDR. The TDR determinations represent an estimate of the total moisture over a specified thickness of soil. This is divided by the thickness of soil to get a mean moisture content. The gravimetric determinations are based on disturbed soil taken from a limited section of a sampled horizon. The limited sample produces reasonable estimates if the horizon has a uniform distribution of moisture. If the moisture content of the horizon varies with depth and only a portion of the thickness of the horizon is sampled, the mean moisture content estimated for the entire horizon will be in error.

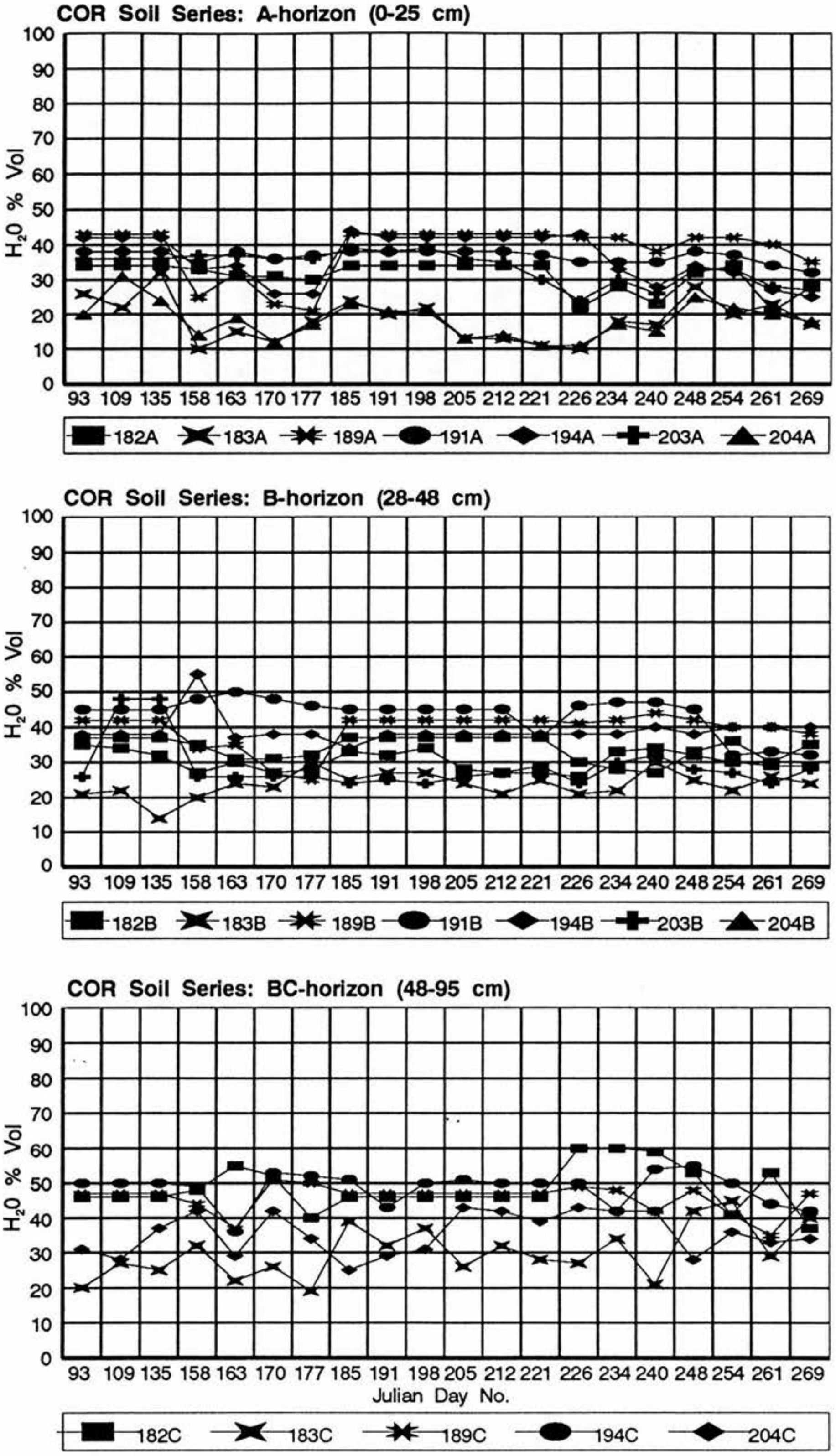


Figure A4.1 Volumetric soil moisture (TDR) for the period April to October for monitoring sites classified as COR Soil Series

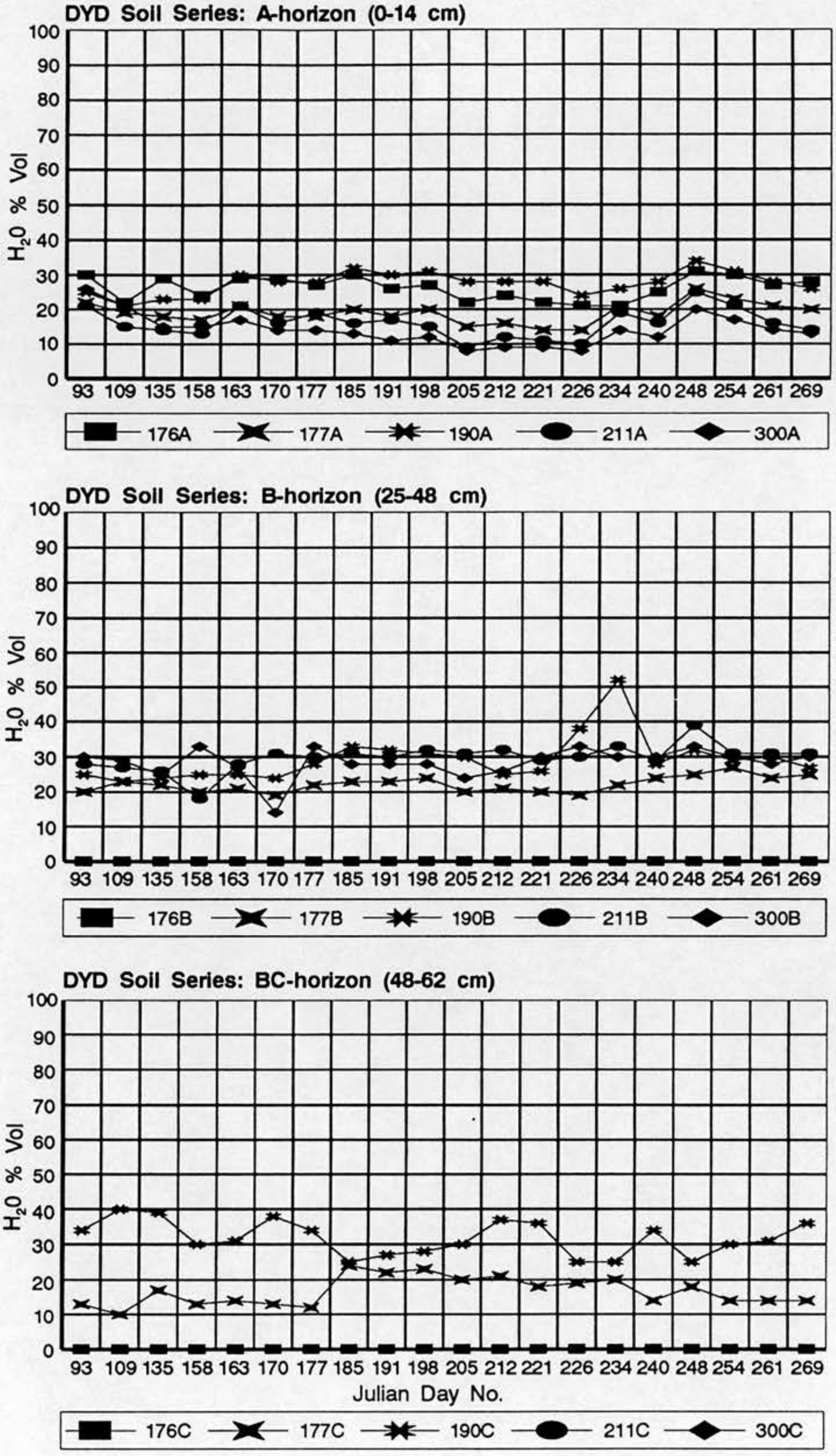


Figure A4.2 Volumetric soil moisture (TDR) for the period April to October for monitoring sites classified as DYD Soil Series

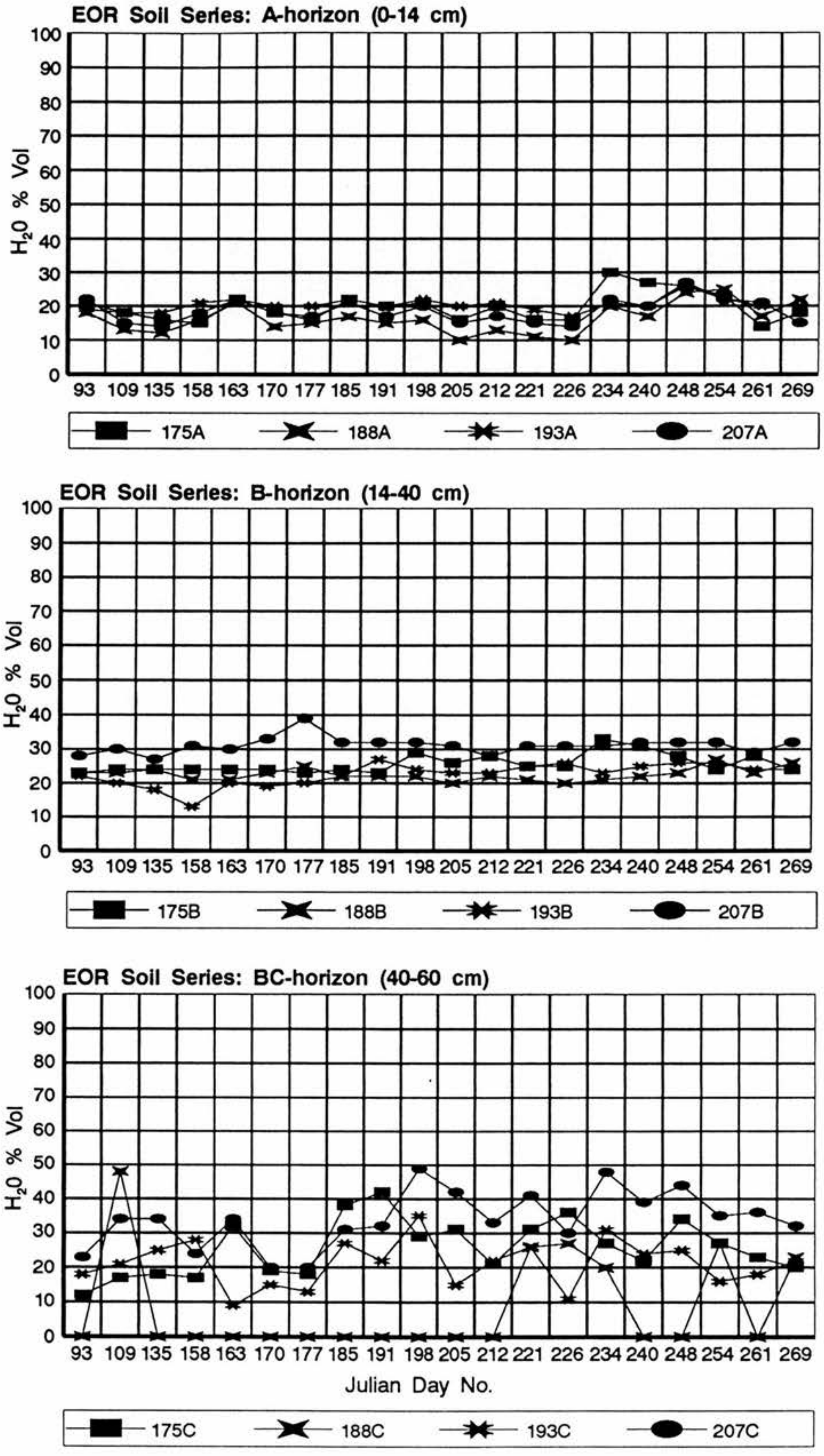
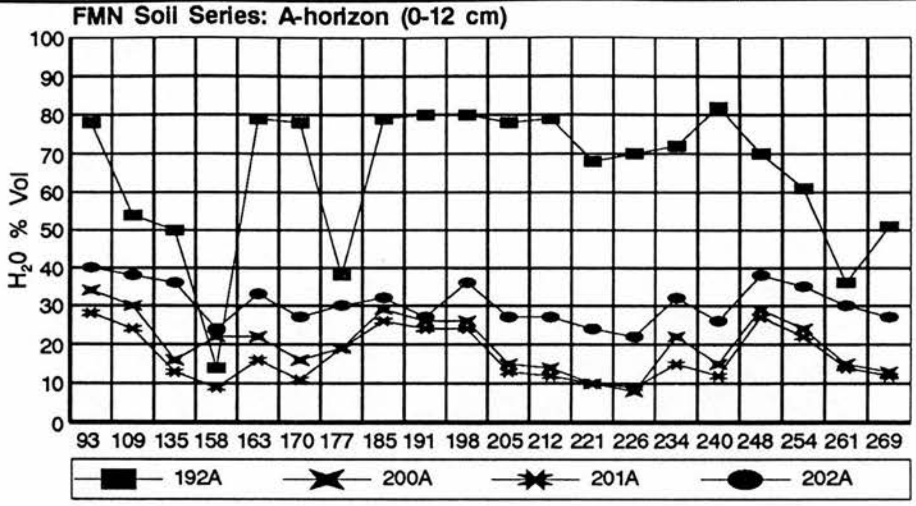
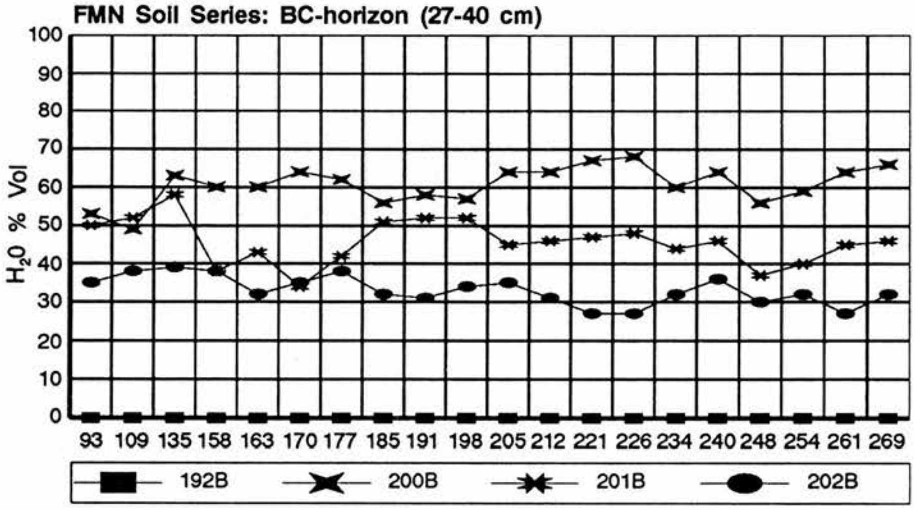


Figure A4.3 Volumetric soil moisture (TDR) for the period April to October for monitoring sites classified as EOR Soil Series





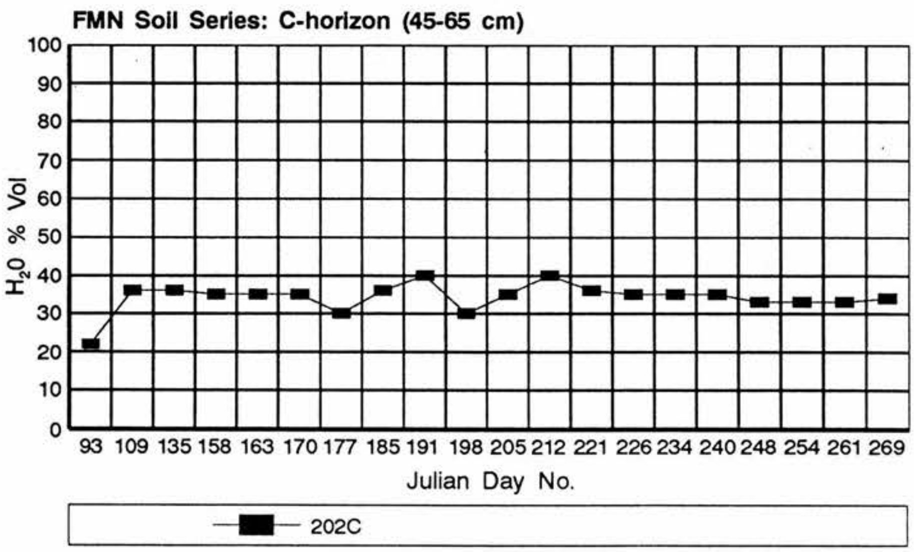
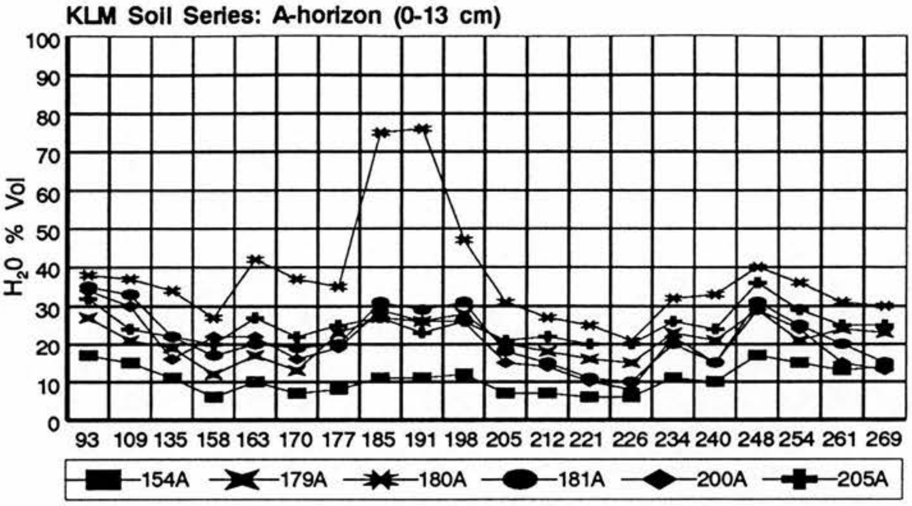
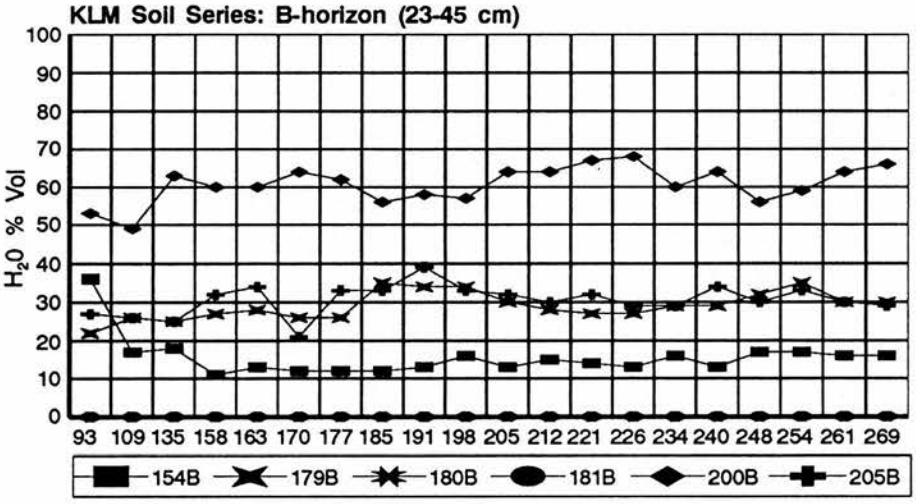


Figure A4.4 Volumetric soil moisture (TDR) for the period April to October for monitoring sites classified as FMN Soil Series





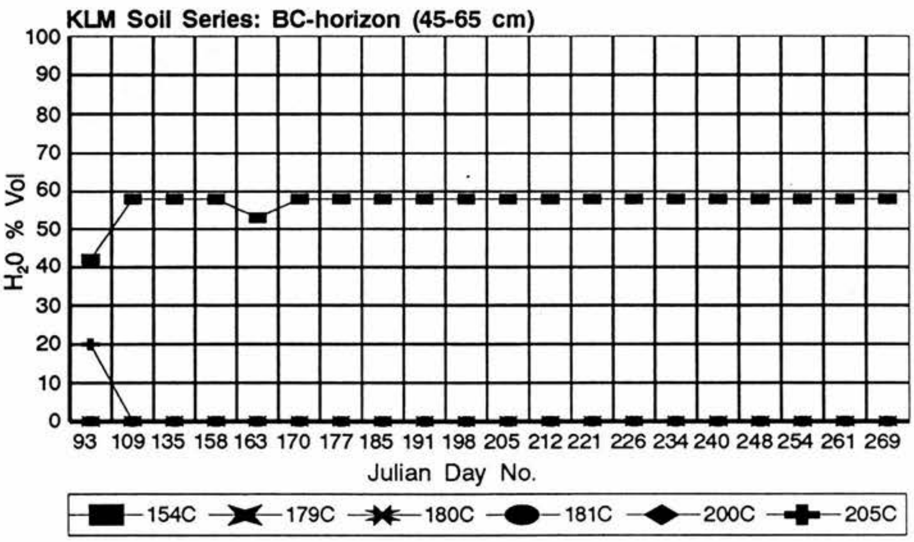


Figure A4.5 Volumetric soil moisture (TDR) for the period April to October for monitoring sites classified as KLM Soil Series

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (h) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	**Date**	**Raw TDR**	**TDR (θ)**	**Gyp (h)**	**Raw Gyp**	**Raw TDR**	**TDR (θ)**	**Gyp (h)**	**Raw Gyp**	**Raw TDR**	**TDR (θ)**	**Gyp (h)**	**Raw Gyp**
154	89/06/07	6.7	5.6	7.0	7	11.0	11.4	1.5	35	0.0	0.0	0.1	102
154	89/06/12	12.4	10.4	10.0	5	14.5	13.1	2.0	27	31.0	53.2	0.1	102
154	89/06/19	8.5	7.1	10.0	4	12.0	11.7	2.0	24	31.2	57.7	0.1	101
154	89/06/26	9.1	7.6	15.0	2	12.6	12.2	3.0	20	0.0	0.0	0.1	103
154	89/07/04	13.6	11.4	2.0	21	14.3	12.2	3.0	19	0.0	0.0	0.1	102
154	89/07/10	13.2	11.0	2.0	29	14.5	12.8	2.0	21	0.0	0.0	0.1	103
154	89/07/17	14.3	11.9	0.3	90	17.7	16.5	2.0	22	0.0	0.0	0.1	103
154	89/07/24	8.5	7.1	4.0	11	13.2	13.3	2.0	24	0.0	0.0	0.1	103
154	89/07/31	8.5	7.1	10.0	4	14.2	14.8	2.0	25	0.0	0.0	0.1	103
154	89/08/09	7.8	6.5	10.0	5	13.2	13.7	2.0	27	0.0	0.0	0.1	103
154	89/08/14	6.7	5.6	10.0	5	12.4	13.3	2.0	28	0.0	0.0	0.1	104
154	89/08/22	13.2	11.0	10.0	5	16.8	15.8	2.0	28	0.0	0.0	0.1	103
154	89/08/28	12.0	10.0	7.0	6	14.5	13.4	2.0	27	0.0	0.0	0.1	104
154	89/09/05	20.5	17.1	0.7	64	20.8	17.4	2.0	24	0.0	0.0	0.1	103
154	89/09/11	18.4	15.3	0.2	94	19.6	16.9	2.0	23	0.0	0.0	0.1	103
154	89/09/18	15.5	12.9	0.2	92	18.0	16.3	2.0	21	0.0	0.0	0.1	102
154	89/09/26	16.8	14.0	0.3	90	18.0	15.6	2.0	23	0.0	0.0	0.1	103
154	90/04/03	20.8	17.3	0.2	91	34.5	35.5	5.0	10	40.0	42.2	0.1	102
154	90/04/19	17.9	14.9	0.2	92	19.2	16.7	2.0	27	0.0	0.0	0.1	104
154	90/05/15	13.6	11.4	0.4	86	18.8	18.3	1.5	35	0.0	0.0	0.1	103
155	89/06/07	28.7	23.9	0.2	92	43.6	43.6	0.1	98	40.0	27.2	0.1	97
155	89/06/12	31.8	26.4	0.1	96	44.6	43.5	0.1	96	42.2	31.1	0.1	97
155	89/06/19	24.2	20.1	0.3	87	41.3	42.8	0.1	97	39.6	30.1	0.1	99
155	89/06/26	26.6	22.1	0.2	93	42.5	43.2	0.1	98	39.8	28.7	0.1	99
155	89/07/04	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
155	89/07/10	0.0	0.0	0.1	100	0.0	0.0	0.1	102	0.0	0.0	0.1	99
155	89/07/17	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
155	89/07/24	0.0	0.0	0.1	101	0.0	0.0	0.1	101	0.0	0.0	0.1	100
155	89/07/31	0.0	0.0	0.1	101	0.0	0.0	0.1	102	0.0	0.0	0.1	101
155	89/08/09	0.0	0.0	0.1	102	0.0	0.0	0.1	101	0.0	0.0	0.1	100
155	89/08/14	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
155	89/08/22	0.0	0.0	0.1	102	0.0	0.0	0.1	100	0.0	0.0	0.1	101
155	89/08/28	46.2	38.4	0.1	96	53.5	48.0	0.1	101	47.4	29.4	0.1	100
155	89/09/05	50.1	41.6	0.1	100	55.2	48.3	0.1	101	49.8	32.6	0.1	99
155	89/09/11	45.4	37.7	0.1	98	51.6	46.0	0.1	100	49.0	36.3	0.1	99
155	89/09/18	41.3	34.3	0.1	100	49.5	45.2	0.1	97	45.6	31.5	0.1	98
155	89/09/26	38.9	32.3	0.1	99	48.4	44.9	0.1	99	43.5	27.9	0.1	100
155	90/04/03	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
155	90/04/19	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
155	90/05/15	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
175	89/06/07	18.4	15.3	1.5	39	25.1	24.3	1.5	36	23.5	17.0	0.4	83
175	89/06/12	25.8	21.5	0.1	100	28.0	24.4	1.5	39	31.4	31.7	0.4	81
175	89/06/19	21.6	18.0	0.1	100	26.0	23.8	1.5	39	24.8	18.6	0.4	81
175	89/06/26	19.6	16.3	3.0	18	24.8	23.2	1.5	38	23.9	18.5	0.4	84
175	89/07/04	25.8	21.5	0.1	99	27.5	23.7	1.5	37	33.6	37.9	0.4	83
175	89/07/10	24.2	20.1	0.1	96	26.4	23.1	1.5	38	34.4	41.8	0.4	84
175	89/07/17	25.4	21.1	0.4	83	31.0	28.6	0.8	53	32.5	29.4	0.4	85

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (*h*) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
175	89/07/24	19.6	16.3	4.0	13	26.6	25.6	1.0	47	30.3	31.4	0.4	86
175	89/07/31	24.2	20.1	1.0	42	29.8	27.6	1.5	34	28.1	20.6	0.3	87
175	89/08/09	19.6	16.3	1.5	33	26.0	24.8	1.5	31	29.8	31.2	0.3	87
175	89/08/14	19.1	15.9	2.0	24	25.7	24.7	1.5	31	31.5	35.8	0.3	88
175	89/08/22	35.8	29.8	0.1	99	38.4	33.2	1.5	32	36.4	27.1	0.3	88
175	89/08/28	33.0	27.4	0.1	97	36.0	31.4	1.5	32	33.0	22.4	1.5	37
175	89/09/05	31.8	26.4	0.1	99	32.9	28.0	1.5	35	35.6	34.0	0.3	87
175	89/09/11	27.9	23.2	0.1	99	28.8	24.5	1.5	35	29.9	26.7	0.3	87
175	89/09/18	16.8	14.0	0.2	94	27.1	27.6	0.7	64	27.3	23.1	0.4	86
175	89/09/26	22.1	18.4	0.8	54	26.1	23.7	0.7	70	25.4	19.9	0.4	86
175	90/04/03	24.7	20.6	0.2	95	26.4	22.8	4.0	12	22.6	12.4	3.0	17
175	90/04/19	22.1	18.4	0.2	92	26.6	24.3	0.7	64	24.5	17.0	1.5	40
175	90/05/15	19.6	16.3	4.0	15	25.6	24.3	0.6	74	24.2	17.7	0.4	83
176	89/06/07	28.8	24.0	0.1	98	0.0	0.0	0.1	102	0.0	0.0	0.1	101
176	89/06/12	35.2	29.3	0.1	102	0.0	0.0	0.1	102	0.0	0.0	0.1	102
176	89/06/19	34.8	28.9	0.1	102	0.0	0.0	0.1	102	0.0	0.0	0.1	102
176	89/06/26	32.5	27.0	0.1	102	0.0	0.0	0.1	102	0.0	0.0	0.1	102
176	89/07/04	35.9	29.8	0.1	102	0.0	0.0	0.1	103	0.0	0.0	0.1	102
176	89/07/10	31.8	26.4	0.1	101	0.0	0.0	0.1	103	0.0	0.0	0.1	103
176	89/07/17	32.5	27.0	0.1	99	0.0	0.0	0.1	101	0.0	0.0	0.1	101
176	89/07/24	27.0	22.5	1.5	35	0.0	0.0	0.1	102	0.0	0.0	0.1	102
176	89/07/31	28.3	23.5	2.0	27	0.0	0.0	0.1	103	0.0	0.0	0.1	103
176	89/08/09	25.8	21.5	1.5	34	0.0	0.0	0.1	102	0.0	0.0	0.1	103
176	89/08/14	25.4	21.1	1.5	31	0.0	0.0	0.1	102	0.0	0.0	0.1	103
176	89/08/22	25.4	21.1	1.0	43	0.0	0.0	0.1	103	0.0	0.0	0.1	103
176	89/08/28	30.0	24.9	0.8	57	0.0	0.0	0.1	103	0.0	0.0	0.1	103
176	89/09/05	37.3	31.0	0.1	102	0.0	0.0	0.1	103	0.0	0.0	0.1	103
176	89/09/11	36.3	30.2	0.1	102	0.0	0.0	0.1	103	0.0	0.0	0.1	103
176	89/09/18	32.5	27.0	0.1	101	0.0	0.0	0.1	101	0.0	0.0	0.1	103
176	89/09/26	33.7	28.0	0.1	101	0.0	0.0	0.1	103	0.0	0.0	0.1	103
176	90/04/03	35.9	29.8	0.1	101	0.0	0.0	0.3	87	0.0	0.0	0.4	83
176	90/04/19	26.6	22.1	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.2	92
176	90/05/15	34.8	28.9	0.2	95	0.0	0.0	0.1	102	0.0	0.0	0.1	102
177	89/06/07	20.7	17.2	0.2	94	22.8	20.1	0.2	91	20.4	13.0	0.6	73
177	89/06/12	25.4	21.1	0.2	91	25.6	21.4	0.2	95	22.6	13.8	0.7	67
177	89/06/19	22.1	18.4	0.2	91	22.8	19.4	0.2	95	20.5	13.3	0.7	67
177	89/06/26	21.6	18.0	0.2	94	24.4	21.7	0.2	92	21.3	12.5	1.0	47
177	89/07/04	24.5	20.4	0.1	97	26.4	23.0	0.2	93	27.0	23.5	1.5	37
177	89/07/10	22.1	18.4	0.2	93	25.6	23.0	0.2	95	25.8	21.9	1.5	35
177	89/07/17	23.4	19.5	0.1	96	26.9	24.1	0.1	97	27.0	22.7	0.7	68
177	89/07/24	17.9	14.9	1.0	50	21.5	19.7	0.1	96	22.3	20.0	0.4	85
177	89/07/31	19.6	16.3	2.0	29	22.9	20.8	0.2	95	23.6	20.6	0.3	90
177	89/08/09	17.2	14.3	1.5	34	21.3	19.7	0.2	94	21.5	18.3	0.3	90
177	89/08/14	16.8	14.0	1.5	39	20.8	19.3	0.2	95	21.5	19.1	0.2	91
177	89/08/22	25.4	21.1	0.3	88	26.1	22.1	0.2	93	25.4	19.9	0.3	90
177	89/08/28	22.1	18.4	0.2	91	26.4	24.2	0.2	93	23.1	13.6	0.3	89
177	89/09/05	31.4	26.1	0.1	98	30.3	24.7	0.2	94	27.3	17.7	0.3	89
177	89/09/11	27.9	23.2	0.1	98	30.4	26.6	0.2	94	25.7	13.6	0.3	89
177	89/09/18	24.7	20.6	0.1	96	27.6	24.4	0.1	96	24.2	14.3	0.2	91
177	89/09/26	24.6	20.5	0.1	96	28.3	25.3	0.1	96	24.5	14.2	0.2	92
177	90/04/03	27.0	22.5	0.2	93	25.3	20.3	7.0	6	18.0	2.8	7.0	6
177	90/04/19	22.9	19.1	0.2	95	25.6	22.6	0.2	93	21.0	9.9	3.0	19

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (*h*) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
177	90/05/15	22.1	18.4	0.1	96	24.7	21.9	0.2	95	23.3	17.0	0.2	95
179	89/06/07	14.3	11.9	0.7	69	25.7	27.1	0.2	93	0.0	0.0	0.1	97
179	89/06/12	20.5	17.1	0.7	68	28.4	27.5	0.3	88	0.0	0.0	0.1	99
179	89/06/19	16.0	13.3	0.7	68	25.1	25.5	0.3	88	0.0	0.0	0.1	99
179	89/06/26	27.5	22.9	0.2	94	30.0	26.1	0.4	84	0.0	0.0	0.1	100
179	89/07/04	33.0	27.4	0.1	96	38.4	34.6	0.1	101	0.0	0.0	0.1	101
179	89/07/10	31.8	26.4	0.1	96	37.7	34.2	0.1	100	0.0	0.0	0.1	101
179	89/07/17	34.1	28.3	0.2	94	38.8	34.5	0.1	98	0.0	0.0	0.1	102
179	89/07/24	24.2	20.1	0.2	93	31.5	29.9	0.1	100	0.0	0.0	0.1	102
179	89/07/31	22.1	18.4	0.4	83	29.1	27.7	0.1	101	0.0	0.0	0.1	103
179	89/08/09	19.1	15.9	0.4	83	27.3	26.8	0.1	101	0.0	0.0	0.1	103
179	89/08/14	18.4	15.3	0.4	83	26.9	26.7	0.1	101	0.0	0.0	0.1	103
179	89/08/22	27.9	23.2	0.4	86	32.4	29.1	0.1	100	0.0	0.0	0.1	102
179	89/08/28	25.4	21.1	0.3	89	31.4	29.1	0.1	100	0.0	0.0	0.1	103
179	89/09/05	35.2	29.3	0.2	94	37.6	32.5	0.1	101	0.0	0.0	0.1	104
179	89/09/11	25.4	21.1	0.2	94	36.1	35.3	0.1	101	0.0	0.0	0.1	104
179	89/09/18	28.3	23.5	0.2	94	33.4	30.4	0.1	100	0.0	0.0	0.1	103
179	89/09/26	27.9	23.2	0.2	94	33.1	30.1	0.1	101	0.0	0.0	0.1	103
179	90/04/03	33.0	27.4	0.3	90	29.1	22.3	3.0	17	0.0	0.0	0.1	103
179	90/04/19	25.4	21.1	0.2	91	28.8	25.7	0.8	52	0.0	0.0	0.1	102
179	90/05/15	22.5	18.7	0.2	92	26.9	24.6	0.1	99	0.0	0.0	0.1	102
180	89/06/07	32.7	27.2	0.2	91	0.0	0.0	0.1	100	0.0	0.0	0.1	100
180	89/06/12	50.8	42.2	0.2	94	0.0	0.0	0.1	101	0.0	0.0	0.1	102
180	89/06/19	44.0	36.6	0.2	94	0.0	0.0	0.1	101	0.0	0.0	0.1	102
180	89/06/26	41.9	34.8	0.2	94	0.0	0.0	0.1	100	0.0	0.0	0.1	101
180	89/07/04	90.5	75.1	0.1	102	0.0	0.0	0.1	102	0.0	0.0	0.1	102
180	89/07/10	91.2	75.7	0.1	102	0.0	0.0	0.1	102	0.0	0.0	0.1	102
180	89/07/17	56.2	46.7	0.1	103	0.0	0.0	0.1	101	0.0	0.0	0.1	105
180	89/07/24	37.2	30.9	0.1	97	0.0	0.0	0.1	103	0.0	0.0	0.1	107
180	89/07/31	33.0	27.4	0.6	79	0.0	0.0	0.1	101	0.0	0.0	0.1	105
180	89/08/09	30.3	25.2	0.6	79	0.0	0.0	0.1	101	0.0	0.0	0.1	105
180	89/08/14	24.7	20.6	1.0	43	0.0	0.0	0.1	103	0.0	0.0	0.1	110
180	89/08/22	38.9	32.3	0.4	85	0.0	0.0	0.1	103	0.0	0.0	0.1	98
180	89/08/28	40.0	33.2	0.6	78	0.0	0.0	0.1	103	0.0	0.0	0.2	93
180	89/09/05	47.7	39.6	0.1	104	0.0	0.0	0.1	103	0.0	0.0	0.1	100
180	89/09/11	42.8	35.6	0.1	104	0.0	0.0	0.1	103	0.0	0.0	0.1	100
180	89/09/18	36.9	30.7	0.1	97	0.0	0.0	0.1	102	0.0	0.0	0.1	103
180	89/09/26	36.2	30.1	0.2	93	0.0	0.0	0.1	103	0.0	0.0	0.1	104
180	90/04/03	45.5	37.8	0.1	101	0.0	0.0	0.1	102	0.0	0.0	0.1	97
180	90/04/19	44.2	36.7	0.1	101	0.0	0.0	0.1	103	0.0	0.0	0.1	102
180	90/05/15	41.0	34.1	0.1	99	0.0	0.0	0.1	103	0.0	0.0	0.1	103
181	89/06/07	20.5	17.1	2.0	22	0.0	0.0	0.1	102	0.0	0.0	0.1	104
181	89/06/12	24.5	20.4	2.0	23	0.0	0.0	0.1	102	0.0	0.0	0.1	103
181	89/06/19	22.9	19.1	2.0	23	0.0	0.0	0.1	102	0.0	0.0	0.1	103
181	89/06/26	24.2	20.1	2.0	22	0.0	0.0	0.1	102	0.0	0.0	0.1	104
181	89/07/04	37.5	31.2	0.1	101	0.0	0.0	0.1	102	0.0	0.0	0.1	104
181	89/07/10	35.2	29.3	0.1	102	0.0	0.0	0.1	103	0.0	0.0	0.1	104
181	89/07/17	36.9	30.7	0.1	99	0.0	0.0	0.1	103	0.0	0.0	0.1	108
181	89/07/24	22.1	18.4	1.5	40	0.0	0.0	0.1	104	0.0	0.0	0.1	100
181	89/07/31	18.4	15.3	5.0	8	0.0	0.0	0.1	102	0.0	0.0	0.1	98
181	89/08/09	13.2	11.0	5.0	8	0.0	0.0	0.1	102	0.0	0.0	0.1	98
181	89/08/14	12.4	10.4	15.0	1	0.0	0.0	0.1	103	0.0	0.0	0.1	120

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (*h*) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
181	89/08/22	23.4	19.5	0.8	53	0.0	0.0	0.1	103	0.0	0.0	0.1	103
181	89/08/28	18.4	15.3	4.0	15	0.0	0.0	0.1	103	0.0	0.0	0.1	103
181	89/09/05	36.9	30.7	0.3	89	0.0	0.0	0.1	103	0.0	0.0	0.1	104
181	89/09/11	30.6	25.4	0.3	89	0.0	0.0	0.1	103	0.0	0.0	0.1	104
181	89/09/18	23.4	19.5	1.5	33	0.0	0.0	0.1	103	0.0	0.0	0.1	103
181	89/09/26	18.4	15.3	7.0	6	0.0	0.0	0.1	103	0.0	0.0	0.1	103
181	90/04/03	42.5	35.3	0.1	99	0.0	0.0	0.1	102	0.0	0.0	4.0	12
181	90/04/19	39.4	32.7	0.1	102	0.0	0.0	0.1	103	0.0	0.0	0.1	104
181	90/05/15	27.0	22.5	0.2	94	0.0	0.0	0.1	101	0.0	0.0	0.1	102
182	89/06/12	37.0	30.8	0.2	95	37.3	31.1	0.2	93	47.0	55.0	0.2	95
182	89/06/19	36.9	30.7	0.2	93	37.3	31.2	0.2	93	45.8	52.0	0.2	95
182	89/06/26	35.9	29.8	0.2	93	37.7	32.2	0.4	82	41.0	39.7	0.4	84
182	89/07/04	41.0	34.1	0.1	100	43.0	36.7	0.1	100	47.0	45.6	0.1	100
182	89/07/10	41.0	34.1	0.2	93	43.0	36.7	0.2	94	47.0	45.6	0.2	92
182	89/07/17	41.0	34.1	0.1	97	43.0	36.7	0.2	95	47.0	45.6	0.3	90
182	89/07/24	41.0	34.1	0.1	97	43.0	36.7	0.2	95	47.0	45.6	0.2	91
182	89/07/31	41.0	34.1	0.1	98	43.0	36.7	0.2	94	47.0	45.6	0.2	92
182	89/08/09	41.0	34.1	0.1	97	43.0	36.7	0.1	101	47.0	45.6	0.1	99
182	89/08/14	27.0	22.5	0.2	95	32.4	29.5	0.2	94	45.8	60.2	0.2	94
182	89/08/22	33.7	28.0	0.1	97	34.1	28.5	0.4	84	47.0	60.4	0.2	95
182	89/08/28	27.9	23.2	0.2	95	30.6	26.7	0.2	93	44.1	59.0	0.1	96
182	89/09/05	38.9	32.3	0.2	95	39.5	33.1	0.2	95	47.7	53.2	0.2	95
182	89/09/11	41.0	34.1	0.1	100	42.8	36.5	0.2	93	45.0	41.0	0.1	97
182	89/09/18	25.4	21.1	0.2	94	31.7	29.6	0.2	94	42.5	53.1	0.2	94
182	89/09/26	33.7	28.0	0.4	84	39.1	35.2	0.1	97	41.0	37.3	0.1	98
182	90/04/03	41.0	34.1	0.1	100	43.0	36.7	0.1	100	47.0	45.6	0.1	100
182	90/04/19	41.0	34.1	0.1	100	43.0	36.7	0.1	100	47.0	45.6	0.1	100
182	90/05/15	41.0	34.1	0.1	100	43.0	36.7	0.1	100	47.0	45.6	0.1	100
183	89/06/07	12.4	10.4	2.0	23	20.0	20.5	0.2	91	26.1	31.7	0.4	81
183	89/06/12	17.9	14.9	0.2	91	24.5	23.7	0.3	87	25.4	22.5	0.8	55
183	89/06/19	14.5	12.1	0.8	54	22.5	22.7	0.4	82	25.2	25.6	1.0	42
183	89/06/26	22.1	18.4	2.0	25	30.6	29.6	0.7	63	27.9	18.8	1.5	38
183	89/07/04	28.3	23.5	0.1	102	29.1	24.6	0.8	52	35.1	39.2	1.5	38
183	89/07/10	24.2	20.1	0.1	96	29.1	26.7	1.0	44	32.4	32.3	1.5	39
183	89/07/17	25.8	21.5	0.2	94	30.2	27.3	1.0	41	34.9	36.8	1.0	42
183	89/07/24	15.5	12.9	10.0	5	23.9	24.1	1.5	32	26.4	26.2	1.0	43
183	89/07/31	16.0	13.3	10.0	3	21.5	20.7	2.0	21	27.1	31.7	1.0	42
183	89/08/09	13.5	11.3	5.0	10	23.6	24.6	1.5	31	26.8	27.7	0.1	101
183	89/08/14	12.4	10.4	15.0	2	20.6	21.3	4.0	15	24.6	27.1	1.5	40
183	89/08/22	22.1	18.4	0.2	95	24.7	21.9	4.0	13	30.3	34.4	1.5	39
183	89/08/28	20.5	17.1	0.2	93	30.0	29.6	4.0	12	28.3	20.7	1.5	39
183	89/09/05	34.1	28.3	0.2	95	31.8	25.3	4.0	12	38.2	42.3	1.5	39
183	89/09/11	23.4	19.5	0.1	99	25.7	22.5	0.3	89	0.0	0.0	0.1	101
183	89/09/18	27.9	23.2	0.2	94	29.8	25.8	4.0	11	31.4	28.7	1.5	38
183	89/09/26	20.5	17.1	0.3	87	25.4	23.5	0.2	94	0.0	0.0	0.1	101
183	90/04/03	31.1	25.9	0.2	91	27.3	20.8	10.0	4	26.2	20.0	5.0	9
183	90/04/19	27.0	22.5	0.2	92	27.0	22.5	1.5	32	28.8	27.0	1.0	45
183	90/05/15	38.9	32.3	0.1	97	24.8	13.6	1.5	31	26.4	24.8	1.0	49
184	89/06/12	0.0	0.0	0.1	96	0.0	0.0	0.2	95	0.0	0.0	0.2	95
184	89/06/19	38.4	31.9	0.2	95	43.0	38.0	0.2	94	0.0	0.0	0.2	95
184	89/06/26	36.8	30.6	0.1	100	42.5	38.1	0.1	98	0.0	0.0	0.2	95
184	89/07/04	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (h) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
184	89/07/10	0.0	0.0	0.1	96	0.0	0.0	0.2	95	0.0	0.0	0.2	92
184	89/07/17	0.0	0.0	0.1	99	0.0	0.0	0.1	97	0.0	0.0	0.2	92
184	89/07/24	0.0	0.0	0.1	100	0.0	0.0	0.1	96	0.0	0.0	0.2	95
184	89/07/31	0.0	0.0	0.1	98	0.0	0.0	0.1	96	0.0	0.0	0.1	96
184	89/08/09	39.4	32.7	0.2	95	40.0	33.5	0.2	93	0.0	0.0	0.2	93
184	89/08/14	42.3	35.1	0.1	99	43.8	37.2	0.1	99	0.0	0.0	0.1	102
184	89/08/22	43.7	36.3	0.1	97	45.2	38.4	0.1	100	0.0	0.0	0.1	97
184	89/08/28	36.3	30.2	0.1	100	44.0	40.4	0.1	100	50.4	52.5	0.1	97
184	89/09/05	44.0	36.6	0.1	100	47.4	41.1	0.1	96	50.3	46.6	0.2	95
184	89/09/11	34.1	28.3	0.2	95	34.9	29.4	0.2	95	43.8	51.2	0.2	95
184	89/09/18	36.3	30.2	0.1	96	40.5	35.8	0.2	93	43.3	40.6	0.1	97
184	89/09/26	20.5	17.1	0.2	91	28.4	27.5	0.2	94	39.8	52.1	0.2	94
184	90/04/03	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
184	90/04/19	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
184	90/05/15	0.0	0.0	0.1	100	0.0	0.0	0.1	100	0.0	0.0	0.1	100
188	89/06/07	19.1	15.9	0.8	56	22.8	20.9	0.2	92	0.0	0.0	0.1	98
188	89/06/12	25.4	21.1	0.2	95	25.3	21.1	0.3	88	0.0	0.0	0.1	97
188	89/06/19	16.8	14.0	3.0	17	23.8	23.3	0.3	88	0.0	0.0	0.1	97
188	89/06/26	17.8	14.8	0.6	74	25.6	25.2	0.4	86	0.0	0.0	0.3	88
188	89/07/04	20.8	17.3	0.2	93	24.3	21.9	0.6	80	0.0	0.0	0.1	99
188	89/07/10	17.9	14.9	0.7	68	23.4	22.3	0.6	78	0.0	0.0	0.1	101
188	89/07/17	19.6	16.3	0.6	76	23.8	21.9	0.6	78	0.0	0.0	0.1	102
188	89/07/24	12.4	10.4	15.0	1	20.0	20.5	0.6	71	0.0	0.0	0.1	101
188	89/07/31	16.0	13.3	7.0	6	22.5	21.9	1.0	46	0.0	0.0	0.1	101
188	89/08/09	13.2	11.0	15.0	2	20.6	20.9	4.0	15	24.2	25.9	1.5	40
188	89/08/14	12.4	10.4	5.0	9	20.0	20.5	2.0	28	24.2	26.9	0.1	102
188	89/08/22	23.4	19.5	0.1	100	24.3	20.6	2.0	24	24.2	19.9	0.1	102
188	89/08/28	20.5	17.1	0.1	98	24.3	22.1	2.0	22	0.0	0.0	0.1	102
188	89/09/05	28.3	23.5	0.1	98	27.9	23.0	0.7	63	0.0	0.0	0.1	101
188	89/09/11	30.6	25.4	0.1	97	31.5	26.7	4.0	11	31.7	26.8	1.5	37
188	89/09/18	20.8	17.3	0.1	97	24.7	22.6	0.2	94	0.0	0.0	0.1	102
188	89/09/26	27.0	22.5	0.2	95	29.3	25.5	4.0	12	28.9	23.2	1.5	38
188	90/04/03	21.6	18.0	15.0	0	25.1	22.6	0.2	95	0.0	0.0	0.6	77
188	90/04/19	15.5	12.9	15.0	0	22.8	22.7	0.1	96	34.4	47.8	0.1	100
188	90/05/15	14.7	12.3	15.0	0	23.4	23.8	0.1	96	0.0	0.0	0.1	101
189	89/06/07	30.6	25.4	0.2	92	37.3	34.4	0.2	93	42.7	44.5	0.1	96
189	89/06/12	38.2	31.7	0.2	92	40.4	34.7	0.2	93	41.9	37.2	0.2	94
189	89/06/19	27.9	23.2	1.0	48	30.4	26.6	0.2	92	40.7	50.8	0.2	92
189	89/06/26	24.7	20.6	0.8	59	27.9	24.8	0.3	88	38.6	49.9	0.2	91
189	89/07/04	52.0	43.2	0.1	100	51.0	41.9	0.1	100	53.0	47.2	0.1	100
189	89/07/10	52.0	43.2	0.1	96	51.0	41.9	0.2	94	53.0	47.2	0.2	91
189	89/07/17	52.0	43.2	0.1	99	51.0	41.9	0.1	100	53.0	47.2	0.2	92
189	89/07/24	52.0	43.2	0.1	97	51.0	41.9	0.2	95	53.0	47.2	0.2	93
189	89/07/31	52.0	43.2	0.1	96	51.0	41.9	0.1	96	53.0	47.2	0.2	94
189	89/08/09	52.0	43.2	0.1	97	51.0	41.9	0.1	97	53.0	47.2	0.2	94
189	89/08/14	51.0	42.4	0.1	99	50.0	41.0	0.1	98	53.0	49.0	0.2	95
189	89/08/22	51.0	42.4	0.1	98	50.5	41.6	0.1	96	53.0	48.2	0.1	96
189	89/08/28	46.2	38.4	0.1	96	50.5	44.0	0.1	96	50.5	41.9	0.1	96
189	89/09/05	50.5	41.9	0.1	97	50.2	41.6	0.1	97	52.8	48.3	0.2	95
189	89/09/11	50.3	41.8	0.2	95	49.2	40.4	0.1	96	49.3	40.9	0.2	94
189	89/09/18	48.8	40.5	0.1	96	48.5	40.2	0.1	96	46.4	34.9	0.2	95
189	89/09/26	42.3	35.1	0.3	90	44.0	37.5	0.1	96	48.4	47.4	0.1	97

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (h) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
189	90/04/03	52.0	43.2	0.1	100	51.0	41.9	0.1	100	53.0	47.2	0.1	100
189	90/04/19	52.0	43.2	0.1	100	51.0	41.9	0.1	100	53.0	47.2	0.1	100
189	90/05/15	52.0	43.2	0.1	100	51.0	41.9	0.1	100	53.0	47.2	0.1	100
190	89/06/07	27.5	22.9	0.2	94	29.3	25.3	0.7	65	31.4	29.5	0.6	75
190	89/06/12	35.9	29.8	0.1	99	32.3	25.2	0.8	56	34.1	31.1	0.6	77
190	89/06/19	33.7	28.0	0.1	100	30.6	23.8	0.8	55	35.6	38.0	0.6	80
190	89/06/26	34.1	28.3	0.1	100	33.4	27.5	0.8	52	35.9	33.8	0.4	82
190	89/07/04	38.1	31.7	0.1	98	39.1	33.0	0.1	99	36.0	24.7	0.4	84
190	89/07/10	36.3	30.2	0.2	94	37.7	32.0	0.1	101	36.0	27.1	0.4	84
190	89/07/17	36.9	30.7	0.1	100	37.3	31.2	0.1	99	36.0	27.7	0.1	101
190	89/07/24	34.1	28.3	0.1	99	35.6	30.4	0.1	100	36.0	30.5	0.3	90
190	89/07/31	33.7	28.0	0.1	96	31.8	25.4	0.1	101	36.0	36.9	0.2	92
190	89/08/09	34.3	28.5	0.1	99	32.1	25.6	0.1	101	36.0	36.3	0.1	98
190	89/08/14	28.6	23.8	0.3	89	39.0	37.6	0.1	100	36.0	24.9	0.2	95
190	89/08/22	0.0	0.0	0.1	100	39.0	51.8	0.1	101	36.0	24.9	0.2	95
190	89/08/28	34.1	28.3	0.1	100	33.7	27.8	0.1	101	36.0	33.7	0.1	96
190	89/09/05	41.0	34.1	0.1	100	39.1	31.5	0.1	100	36.0	24.7	0.1	100
190	89/09/11	36.9	30.7	0.1	100	35.9	29.3	0.1	101	36.0	30.1	0.1	102
190	89/09/18	33.7	28.0	0.2	93	35.3	30.1	0.1	100	36.0	31.1	0.1	100
190	89/09/26	31.8	26.4	0.2	93	32.3	27.2	0.1	100	36.0	35.9	0.1	101
190	90/04/03	30.1	25.0	0.2	92	29.8	24.7	0.6	71	33.7	34.4	0.7	61
190	90/04/19	25.4	21.1	0.2	92	26.8	23.0	0.1	99	33.8	39.7	0.2	91
190	90/05/15	27.8	23.1	0.2	91	28.9	24.5	0.1	97	35.0	39.3	0.2	95
191	89/06/07	42.3	35.1	0.2	95	51.9	47.9	0.1	96	0.0	0.0	0.2	94
191	89/06/12	45.4	37.7	0.2	95	54.4	49.7	0.1	97	0.0	0.0	0.2	95
191	89/06/19	43.1	35.8	0.1	96	52.5	48.3	0.1	96	0.0	0.0	0.1	96
191	89/06/26	44.2	36.7	0.2	95	51.5	46.5	0.2	95	0.0	0.0	0.2	95
191	89/07/04	46.0	38.2	0.1	100	51.0	44.9	0.1	100	0.0	0.0	0.1	100
191	89/07/10	46.0	38.2	0.1	100	51.0	44.9	0.1	102	0.0	0.0	0.1	97
191	89/07/17	46.0	38.2	0.1	103	51.0	44.9	0.2	92	0.0	0.0	0.1	100
191	89/07/24	46.0	38.2	0.1	102	51.0	44.9	0.1	97	0.0	0.0	0.1	100
191	89/07/31	46.0	38.2	0.1	103	51.0	44.9	0.1	96	0.0	0.0	0.1	101
191	89/08/09	44.8	37.2	0.1	103	44.8	37.2	0.1	96	52.7	57.0	0.1	101
191	89/08/14	41.7	34.6	0.1	97	50.6	46.4	0.1	98	0.0	0.0	0.1	101
191	89/08/22	41.7	34.6	0.1	97	51.0	47.1	0.1	97	0.0	0.0	0.1	97
191	89/08/28	41.9	34.8	0.1	98	51.0	47.0	0.1	96	0.0	0.0	0.1	96
191	89/09/05	45.4	37.7	0.1	97	51.0	45.2	0.2	95	0.0	0.0	0.2	95
191	89/09/11	44.0	36.6	0.1	96	40.8	32.3	0.2	93	0.0	0.0	0.1	96
191	89/09/18	41.0	34.1	0.1	97	40.0	32.7	0.2	94	0.0	0.0	0.1	98
191	89/09/26	38.9	32.3	0.1	96	38.4	31.7	0.1	98	0.0	0.0	0.1	96
191	90/04/03	46.0	38.2	0.1	100	51.0	44.9	0.1	100	0.0	0.0	0.1	100
191	90/04/19	46.0	38.2	0.1	100	51.0	44.9	0.1	100	0.0	0.0	0.1	100
191	90/05/15	46.0	38.2	0.1	100	51.0	44.9	0.1	100	0.0	0.0	0.1	100
192	89/06/07	16.2	13.5	0.1	101	0.0	0.0	0.1	100	0.0	0.0	0.1	99
192	89/06/12	95.0	78.8	0.1	102	0.0	0.0	0.1	101	0.0	0.0	0.1	103
192	89/06/19	94.5	78.4	0.1	103	0.0	0.0	0.1	101	0.0	0.0	0.1	106
192	89/06/26	45.2	37.6	0.1	102	0.0	0.0	0.1	101	0.0	0.0	0.1	105
192	89/07/04	95.0	78.8	0.1	102	0.0	0.0	0.1	102	0.0	0.0	0.1	101
192	89/07/10	96.2	79.8	0.1	103	0.0	0.0	0.1	103	0.0	0.0	0.1	102
192	89/07/17	96.2	79.8	0.1	104	0.0	0.0	0.1	104	0.0	0.0	0.1	104
192	89/07/24	94.5	78.4	0.1	103	0.0	0.0	0.1	104	0.0	0.0	0.1	103
192	89/07/31	95.0	78.8	0.1	103	0.0	0.0	0.1	102	0.0	0.0	0.1	102

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (*h*) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
192	89/08/09	81.9	68.0	0.1	103	0.0	0.0	0.1	102	0.0	0.0	0.1	102
192	89/08/14	84.9	70.5	0.1	103	0.0	0.0	0.1	103	0.0	0.0	0.1	103
192	89/08/22	87.0	72.2	0.1	103	0.0	0.0	0.1	104	0.0	0.0	0.1	103
192	89/08/28	98.8	82.0	0.1	103	0.0	0.0	0.1	103	0.0	0.0	0.1	102
192	89/09/05	84.9	70.5	0.1	103	0.0	0.0	0.1	103	0.0	0.0	0.1	103
192	89/09/11	73.0	60.6	0.1	103	0.0	0.0	0.1	103	0.0	0.0	0.1	103
192	89/09/18	43.7	36.3	0.1	103	0.0	0.0	0.1	103	0.0	0.0	0.1	104
192	89/09/26	61.0	50.6	0.1	103	0.0	0.0	0.1	103	0.0	0.0	0.1	103
192	90/04/03	94.5	78.4	0.1	104	0.0	0.0	0.1	101	0.0	0.0	0.3	88
192	90/04/19	65.2	54.1	0.1	104	0.0	0.0	0.1	102	0.0	0.0	0.2	95
192	90/05/15	60.0	49.8	0.1	104	0.0	0.0	0.1	103	0.0	0.0	0.1	104
193	89/06/07	25.4	21.1	0.2	95	19.5	13.3	2.0	27	24.3	28.2	0.1	101
193	89/06/12	26.6	22.1	0.1	98	24.7	19.7	2.0	26	20.1	8.9	0.1	100
193	89/06/19	24.2	20.1	0.1	98	23.4	19.1	2.0	28	21.5	14.7	0.1	102
193	89/06/26	24.2	20.1	0.1	100	23.9	19.8	2.0	30	21.3	13.3	0.1	101
193	89/07/04	26.6	22.1	0.1	98	26.4	21.9	0.6	72	28.5	27.1	0.1	101
193	89/07/10	24.2	20.1	0.1	99	29.3	27.0	0.2	91	28.2	21.7	0.1	102
193	89/07/17	25.8	21.5	0.1	100	28.0	24.4	0.1	98	32.6	34.7	0.1	102
193	89/07/24	23.4	19.5	0.1	98	26.1	23.0	0.1	98	23.6	15.4	0.1	102
193	89/07/31	25.4	21.1	0.1	98	26.6	22.7	0.1	98	26.4	21.8	0.1	102
193	89/08/09	22.9	19.1	0.1	97	27.3	24.9	0.1	96	28.7	26.3	0.1	101
193	89/08/14	20.8	17.3	0.1	96	27.3	25.9	0.1	97	22.6	11.0	0.1	102
193	89/08/22	25.4	21.1	0.1	98	27.0	23.3	0.1	97	30.5	31.2	0.1	101
193	89/08/28	23.4	19.5	0.1	97	27.9	25.4	0.1	97	28.1	23.8	0.1	102
193	89/09/05	31.4	26.1	0.1	100	31.4	26.1	0.1	98	31.0	25.2	0.1	103
193	89/09/11	25.8	21.5	0.1	98	29.3	26.1	0.1	97	26.1	16.3	0.1	103
193	89/09/18	24.2	20.1	0.1	98	27.3	24.3	0.1	98	25.4	17.9	0.1	103
193	89/09/26	24.2	20.1	0.1	98	27.0	23.9	0.1	98	26.9	22.2	0.1	103
193	90/04/03	23.0	19.1	0.2	91	24.8	21.5	4.0	13	23.6	17.6	0.7	69
193	90/04/19	21.6	18.0	0.2	95	23.4	20.4	0.2	94	23.9	20.7	0.4	85
193	90/05/15	21.6	18.0	0.2	94	22.0	18.5	0.2	95	24.5	24.6	0.1	101
194	89/06/07	3.4	2.9	0.1	96	42.8	55.2	0.2	95	48.4	49.4	0.1	96
194	89/06/12	41.0	34.1	0.1	96	43.2	37.0	0.2	95	43.5	36.5	0.2	95
194	89/06/19	31.8	26.4	0.2	93	40.7	38.2	0.2	93	48.5	53.3	0.2	93
194	89/06/26	31.4	26.1	0.3	90	40.2	37.8	0.2	91	47.6	51.7	0.2	91
194	89/07/04	52.6	43.7	0.2	92	44.9	33.5	0.2	94	50.3	50.8	0.2	91
194	89/07/10	50.5	41.9	0.2	93	47.7	38.2	0.1	97	48.9	42.6	0.3	90
194	89/07/17	51.0	42.4	0.2	94	48.0	38.4	0.1	97	52.0	49.8	0.3	89
194	89/07/24	51.0	42.4	0.1	101	48.0	38.4	0.1	100	52.4	50.7	0.2	92
194	89/07/31	51.0	42.4	0.1	102	48.0	38.4	0.1	100	52.0	49.8	0.2	93
194	89/08/09	51.0	42.4	0.1	100	48.0	38.4	0.1	96	52.0	49.8	0.2	95
194	89/08/14	51.3	42.6	0.2	95	48.0	38.3	0.1	100	52.0	49.8	0.1	96
194	89/08/22	39.4	32.7	0.2	91	43.5	38.1	0.1	101	45.8	41.8	0.1	98
194	89/08/28	34.1	28.3	0.2	91	42.5	39.5	0.2	91	50.0	53.9	0.2	95
194	89/09/05	41.3	34.3	0.1	102	44.1	38.0	0.2	91	51.3	54.6	0.2	95
194	89/09/11	38.9	32.3	0.1	99	44.3	39.5	0.2	91	49.7	50.3	0.2	95
194	89/09/18	32.5	27.0	0.1	99	42.1	39.8	0.2	91	45.8	44.0	0.2	95
194	89/09/26	30.1	25.0	0.1	96	41.0	39.6	0.1	98	44.3	42.2	0.2	95
194	90/04/03	51.0	42.4	0.1	100	48.0	38.4	0.1	100	52.0	49.8	0.1	100
194	90/04/19	51.0	42.4	0.1	100	48.0	38.4	0.1	100	52.0	49.8	0.1	100
194	90/05/15	51.0	42.4	0.1	100	48.0	38.4	0.1	100	52.0	49.8	0.1	100

Table A4.1 Original field TDR and gypsum block data with matching volumetric moisture (θ) and head (h) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
200	89/06/07	26.0	21.6	0.8	59	55.0	60.2	0.2	95	0.0	0.0	0.1	100
200	89/06/12	26.6	22.1	0.4	86	55.0	59.9	0.2	94	0.0	0.0	0.1	100
200	89/06/19	19.1	15.9	0.4	86	55.0	63.6	0.2	94	0.0	0.0	0.1	100
200	89/06/26	22.7	18.9	1.5	36	55.0	61.8	0.3	90	0.0	0.0	0.1	100
200	89/07/04	35.2	29.3	0.1	100	55.0	55.5	0.1	96	0.0	0.0	0.1	100
200	89/07/10	31.4	26.1	0.1	99	55.0	57.5	0.1	97	0.0	0.0	0.1	100
200	89/07/17	31.8	26.4	0.1	102	55.0	57.3	0.1	102	0.0	0.0	0.1	102
200	89/07/24	18.4	15.3	3.0	20	55.0	63.9	0.1	102	0.0	0.0	0.1	102
200	89/07/31	17.2	14.3	5.0	10	55.0	64.5	0.1	101	0.0	0.0	0.1	100
200	89/08/09	12.0	10.0	5.0	10	55.0	67.1	0.1	101	0.0	0.0	0.1	100
200	89/08/14	10.1	8.5	10.0	3	55.0	68.0	0.1	102	0.0	0.0	0.1	102
200	89/08/22	25.8	21.5	3.0	17	55.0	60.2	0.1	101	0.0	0.0	0.1	97
200	89/08/28	17.9	14.9	5.0	8	55.0	64.2	0.1	100	0.0	0.0	0.1	100
200	89/09/05	35.2	29.3	2.0	24	55.0	55.5	0.1	100	0.0	0.0	0.1	101
200	89/09/11	28.9	24.0	2.0	24	55.0	58.7	0.1	100	0.0	0.0	0.1	101
200	89/09/18	18.4	15.3	7.0	7	55.0	63.9	0.1	100	0.0	0.0	0.1	101
200	89/09/26	15.1	12.6	15.0	2	55.0	65.6	0.1	100	0.0	0.0	0.1	102
200	90/04/03	40.4	33.6	0.1	99	55.0	53.0	0.1	100	0.0	0.0	0.1	100
200	90/04/19	35.9	29.8	0.1	100	50.5	49.2	0.1	102	0.0	0.0	0.1	103
200	90/05/15	19.6	16.3	2.0	22	55.0	63.3	0.1	100	0.0	0.0	0.1	102
201	89/06/07	11.2	9.4	4.0	13	32.6	37.7	0.2	95	0.0	0.0	0.1	98
201	89/06/12	19.6	16.3	7.0	7	39.7	43.0	0.3	87	0.0	0.0	0.1	98
201	89/06/19	13.2	11.0	7.0	7	30.8	34.4	0.3	87	0.0	0.0	0.1	98
201	89/06/26	22.9	19.1	1.5	39	40.0	41.7	0.1	101	0.0	0.0	0.1	100
201	89/07/04	31.8	26.4	0.1	98	50.0	50.6	0.1	100	0.0	0.0	0.1	99
201	89/07/10	28.3	23.5	0.1	98	50.0	52.3	0.1	102	0.0	0.0	0.1	98
201	89/07/17	28.3	23.5	0.1	100	50.0	52.3	0.1	100	0.0	0.0	0.1	100
201	89/07/24	16.0	13.3	3.0	20	40.0	45.1	0.1	103	0.0	0.0	0.1	100
201	89/07/31	14.3	11.9	7.0	6	40.0	46.0	0.1	102	0.0	0.0	0.1	101
201	89/08/09	12.0	10.0	7.0	6	40.0	47.1	0.1	102	0.0	0.0	0.1	101
201	89/08/14	11.2	9.4	15.0	1	40.0	47.5	0.8	56	0.0	0.0	0.1	102
201	89/08/22	17.9	14.9	15.0	2	40.0	44.2	0.2	95	0.0	0.0	0.1	102
201	89/08/28	14.3	11.9	10.0	3	40.0	46.0	0.3	88	0.0	0.0	0.1	102
201	89/09/05	33.0	27.4	0.7	66	40.0	36.7	0.1	100	0.0	0.0	0.1	102
201	89/09/11	25.8	21.5	0.7	66	40.0	40.2	0.1	100	0.0	0.0	0.1	102
201	89/09/18	16.8	14.0	3.0	17	40.0	44.7	0.2	93	0.0	0.0	0.1	102
201	89/09/26	14.7	12.3	15.0	2	40.0	45.7	0.4	84	0.0	0.0	0.1	102
201	90/04/03	33.7	28.0	0.2	93	50.0	49.6	0.7	69	0.0	0.0	0.4	85
201	90/04/19	29.5	24.5	0.1	96	50.6	52.5	0.7	70	0.0	0.0	0.1	102
201	90/05/15	16.0	13.3	3.0	18	50.0	58.4	0.6	73	0.0	0.0	0.1	101
202	89/06/07	28.3	23.5	3.0	17	39.1	37.9	0.1	96	40.0	34.6	0.2	95
202	89/06/12	39.4	32.7	0.2	94	38.7	31.9	0.2	95	40.0	35.2	0.2	95
202	89/06/19	33.0	27.4	0.2	94	38.8	35.1	0.2	95	40.0	35.2	0.2	95
202	89/06/26	35.9	29.8	0.4	84	41.6	37.5	0.2	91	40.0	30.4	0.2	95
202	89/07/04	38.4	31.9	0.2	94	38.1	31.6	0.2	93	40.0	36.2	0.2	95
202	89/07/10	33.0	27.4	0.8	55	36.0	31.4	0.3	89	40.0	39.8	0.1	98
202	89/07/17	43.1	35.8	0.4	83	42.1	34.5	0.1	98	40.0	29.6	0.1	98
202	89/07/24	32.5	27.0	7.0	6	38.8	35.3	0.1	96	40.0	35.2	0.1	98
202	89/07/31	33.0	27.4	10.0	3	35.7	31.1	0.4	81	40.0	40.2	0.1	97
202	89/08/09	29.5	24.5	10.0	3	31.0	26.6	0.4	81	35.1	36.0	0.1	97
202	89/08/14	26.6	22.1	15.0	1	30.0	26.6	4.0	12	34.2	35.4	0.1	97

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (h) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	**Date**	**Raw TDR**	**TDR (θ)**	**Gyp (h)**	**Raw Gyp**	**Raw TDR**	**TDR (θ)**	**Gyp (h)**	**Raw Gyp**	**Raw TDR**	**TDR (θ)**	**Gyp (h)**	**Raw Gyp**
202	89/08/22	38.4	31.9	0.2	94	38.8	32.4	5.0	9	40.0	35.2	0.1	98
202	89/08/28	31.4	26.1	4.0	15	38.8	35.9	5.0	9	40.0	35.2	0.1	98
202	89/09/05	46.2	38.4	0.2	95	40.0	30.1	0.1	96	40.0	33.2	0.1	97
202	89/09/11	42.3	35.1	0.2	95	40.3	32.5	0.1	96	40.0	32.6	0.1	97
202	89/09/18	35.9	29.8	1.0	43	33.4	26.6	0.3	87	35.4	32.6	0.1	97
202	89/09/26	33.0	27.4	5.0	9	36.4	32.0	0.6	80	37.9	33.9	0.1	96
202	90/04/03	48.5	40.3	0.3	90	44.4	34.9	2.0	28	38.6	22.5	0.2	93
202	90/04/19	46.2	38.4	0.2	91	46.0	38.1	0.2	95	45.0	35.8	0.2	93
202	90/05/15	43.7	36.3	0.2	92	46.0	39.3	0.1	97	45.0	35.8	0.1	96
203	89/06/07	44.9	37.3	0.2	93	36.0	25.5	0.1	98	0.0	0.0	0.1	96
203	89/06/12	44.0	36.6	0.1	101	36.0	25.9	0.1	101	0.0	0.0	0.1	100
203	89/06/19	43.7	36.3	0.1	101	36.0	26.1	0.1	101	0.0	0.0	0.1	100
203	89/06/26	43.7	36.3	0.1	100	36.0	26.1	0.1	102	0.0	0.0	0.1	102
203	89/07/04	47.0	39.0	0.1	99	36.0	24.4	0.1	99	0.0	0.0	0.1	102
203	89/07/10	45.7	38.0	0.1	99	36.0	25.0	0.1	99	0.0	0.0	0.1	104
203	89/07/17	47.3	39.3	0.1	98	36.0	24.3	0.1	100	0.0	0.0	0.1	103
203	89/07/24	43.1	35.8	0.1	100	36.0	26.4	0.1	103	0.0	0.0	0.1	103
203	89/07/31	41.9	34.8	0.1	99	36.0	27.0	0.1	101	0.0	0.0	0.1	97
203	89/08/09	35.9	29.8	0.1	99	35.3	29.0	0.1	101	0.0	0.0	0.1	97
203	89/08/14	28.9	24.0	0.8	54	28.7	23.8	1.0	44	0.0	0.0	0.1	103
203	89/08/22	36.0	29.9	0.1	96	36.0	29.9	0.1	97	0.0	0.0	0.1	101
203	89/08/28	31.7	26.4	0.3	88	36.0	32.0	0.4	83	0.0	0.0	0.1	101
203	89/09/05	39.9	33.2	0.1	99	36.0	27.9	0.1	100	0.0	0.0	0.1	101
203	89/09/11	39.9	33.2	0.1	99	35.0	26.6	0.1	100	0.0	0.0	0.1	101
203	89/09/18	33.7	28.0	0.1	98	30.5	23.8	0.1	99	0.0	0.0	0.1	100
203	89/09/26	32.5	27.0	0.2	91	33.6	28.4	0.3	90	0.0	0.0	0.1	100
203	90/04/03	43.0	35.7	0.1	100	36.0	26.4	0.1	100	0.0	0.0	0.6	80
203	90/04/19	0.0	0.0	0.1	103	36.0	47.8	0.1	100	0.0	0.0	0.1	100
203	90/05/15	0.0	0.0	0.1	100	36.0	47.8	0.1	101	0.0	0.0	0.1	99
204	89/06/07	16.9	14.1	0.6	75	26.9	27.4	0.1	97	34.9	42.2	0.2	95
204	89/06/12	22.9	19.1	0.2	93	31.4	30.3	0.1	99	32.5	28.8	0.1	96
204	89/06/19	14.7	12.3	1.5	34	25.7	26.9	0.1	98	34.0	42.1	0.2	95
204	89/06/26	20.3	16.9	0.7	69	28.4	27.6	0.3	90	32.4	33.5	0.1	96
204	89/07/04	27.9	23.2	0.2	95	35.1	32.8	0.4	85	33.4	25.0	0.1	96
204	89/07/10	24.7	20.6	0.2	94	33.2	31.8	0.4	84	33.7	28.8	0.1	97
204	89/07/17	24.7	20.6	0.1	96	34.9	34.0	0.2	93	35.7	31.1	0.1	96
204	89/07/24	16.0	13.3	1.5	39	27.0	28.0	0.6	79	35.4	43.2	0.1	97
204	89/07/31	17.2	14.3	1.5	37	26.9	27.3	1.5	35	35.0	42.5	0.1	97
204	89/08/09	13.6	11.4	1.5	37	25.3	26.9	1.5	33	32.6	39.1	0.1	96
204	89/08/14	13.2	11.0	1.5	32	24.8	26.4	1.0	41	33.8	43.1	0.1	96
204	89/08/22	20.6	17.2	0.6	79	32.4	32.7	1.0	43	38.3	41.6	0.1	96
204	89/08/28	18.4	15.3	0.6	71	32.4	33.9	1.0	43	38.3	41.6	0.1	96
204	89/09/05	30.6	25.4	0.1	97	35.6	32.1	1.0	45	34.8	27.5	0.1	97
204	89/09/11	26.1	21.7	0.2	95	32.4	30.0	1.0	45	35.9	35.6	0.1	96
204	89/09/18	23.4	19.5	0.2	92	30.6	28.9	1.0	48	33.7	33.2	0.1	96
204	89/09/26	21.6	18.0	0.4	82	29.8	28.9	0.8	52	33.4	33.8	0.1	96
204	90/04/03	24.0	20.0	0.1	97	35.0	34.6	0.3	90	35.9	31.2	2.0	24
204	90/04/19	37.1	30.8	0.1	96	39.6	34.2	0.1	97	37.4	27.5	0.4	83
204	90/05/15	28.9	24.0	0.1	97	35.1	32.3	0.1	99	38.3	37.0	0.1	99
205	89/06/07	23.4	19.5	0.7	62	32.8	32.0	1.0	45	0.0	0.0	0.1	97
205	89/06/12	33.0	27.4	0.2	91	38.0	34.1	1.5	40	0.0	0.0	0.1	97

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (h) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
205	89/06/19	27.0	22.5	0.4	81	25.8	20.9	1.0	41	0.0	0.0	0.2	91
205	89/06/26	30.1	25.0	0.3	88	36.1	33.0	1.5	38	0.0	0.0	0.1	98
205	89/07/04	33.0	27.4	0.1	96	37.2	33.0	1.0	44	0.0	0.0	0.1	98
205	89/07/10	27.9	23.2	0.2	94	39.6	38.7	1.0	49	0.0	0.0	0.1	99
205	89/07/17	31.8	26.4	0.4	82	36.5	32.6	0.1	102	0.0	0.0	0.1	100
205	89/07/24	24.7	20.6	1.5	37	33.7	32.4	0.1	101	0.0	0.0	0.1	101
205	89/07/31	25.9	21.6	2.0	28	32.1	29.8	0.1	100	0.0	0.0	0.1	103
205	89/08/09	24.2	20.1	2.0	26	33.2	32.1	2.0	26	0.0	0.0	0.1	100
205	89/08/14	23.4	19.5	2.0	25	30.9	29.4	0.1	100	0.0	0.0	0.1	101
205	89/08/22	31.8	26.4	0.2	94	34.0	29.4	0.1	98	0.0	0.0	0.1	103
205	89/08/28	28.3	23.5	0.6	78	35.8	33.6	0.2	95	0.0	0.0	0.1	101
205	89/09/05	43.7	36.3	0.1	100	39.1	30.2	0.1	96	0.0	0.0	0.1	101
205	89/09/11	34.8	28.9	0.1	99	37.5	32.6	0.1	100	0.0	0.0	0.1	101
205	89/09/18	30.6	25.4	0.4	82	33.7	29.6	0.1	100	0.0	0.0	0.1	101
205	89/09/26	30.6	25.4	0.8	55	33.2	28.9	0.1	100	0.0	0.0	0.1	101
205	90/04/03	38.0	31.6	0.1	97	34.8	27.3	0.6	71	31.0	19.6	1.5	38
205	90/04/19	28.2	23.5	0.7	65	29.8	25.6	0.2	95	0.0	0.0	0.8	55
205	90/05/15	27.0	22.5	0.8	56	28.9	24.9	0.1	97	0.0	0.0	0.2	95
207	89/06/07	21.6	18.0	1.0	47	31.4	31.0	0.2	94	30.5	24.0	0.7	68
207	89/06/12	25.8	21.5	0.3	89	32.4	30.1	0.2	93	35.2	34.1	0.6	71
207	89/06/19	22.0	18.3	1.0	50	33.0	32.9	0.2	92	30.0	19.9	0.7	70
207	89/06/26	20.8	17.3	1.5	34	36.8	38.6	0.2	95	25.4	2.1	0.7	68
207	89/07/04	24.7	20.6	0.7	67	33.7	32.4	0.2	92	35.0	31.3	0.7	68
207	89/07/10	20.6	17.2	2.0	23	31.8	31.9	0.2	93	34.0	32.1	0.7	68
207	89/07/17	23.4	19.5	2.0	23	33.1	32.3	0.2	93	41.9	49.4	0.6	75
207	89/07/24	17.9	14.9	10.0	4	30.3	31.4	0.2	93	37.2	42.3	0.4	84
207	89/07/31	20.5	17.1	4.0	11	28.7	28.0	0.2	92	32.5	33.2	0.4	83
207	89/08/09	17.9	14.9	5.0	8	29.8	30.7	0.2	93	36.2	40.7	0.4	82
207	89/08/14	17.2	14.3	7.0	7	29.8	31.1	0.2	94	31.8	29.6	0.4	82
207	89/08/22	26.6	22.1	0.4	86	33.1	30.7	0.1	96	41.4	48.2	0.4	81
207	89/08/28	24.2	20.1	1.0	45	32.9	31.8	0.2	95	37.7	39.1	0.4	81
207	89/09/05	33.0	27.4	0.2	92	36.5	32.0	0.1	96	41.9	43.8	0.2	92
207	89/09/11	27.0	22.5	0.2	92	33.9	31.6	0.1	96	36.7	35.1	0.2	92
207	89/09/18	24.7	20.6	0.7	67	31.0	28.9	0.2	93	35.1	36.0	0.2	92
207	89/09/26	18.4	15.3	1.5	35	30.5	31.5	0.2	94	33.1	31.7	0.2	92
207	90/04/03	27.0	22.5	0.3	89	31.4	28.3	3.0	17	30.1	22.8	5.0	8
207	90/04/19	18.4	15.3	0.8	52	29.2	29.7	0.3	90	32.9	33.6	4.0	15
207	90/05/15	17.1	14.3	4.0	14	26.9	27.3	0.3	90	31.4	33.5	0.3	88
211	89/06/07	16.0	13.3	0.7	62	19.1	17.5	0.4	82	0.0	0.0	0.1	100
211	89/06/12	25.7	21.4	0.1	99	30.6	27.8	0.6	75	0.0	0.0	0.1	99
211	89/06/19	19.6	16.3	0.2	95	30.5	30.9	0.6	78	0.0	0.0	0.1	100
211	89/06/26	22.9	19.1	0.1	97	31.5	30.5	0.7	64	0.0	0.0	0.1	100
211	89/07/04	19.6	16.3	0.1	97	30.5	30.9	0.7	63	0.0	0.0	0.1	102
211	89/07/10	20.5	17.1	0.4	84	30.3	30.1	1.0	47	0.0	0.0	0.1	101
211	89/07/17	18.4	15.3	0.8	54	31.1	32.3	2.0	30	0.0	0.0	0.1	101
211	89/07/24	10.8	9.0	15.0	2	27.0	30.6	5.0	8	0.0	0.0	0.1	102
211	89/07/31	14.7	12.3	4.0	13	30.0	32.5	5.0	8	0.0	0.0	0.1	101
211	89/08/09	13.5	11.3	4.0	11	27.0	29.2	5.0	8	0.0	0.0	0.1	101
211	89/08/14	12.4	10.4	4.0	12	27.0	29.8	5.0	10	0.0	0.0	0.1	102
211	89/08/22	22.9	19.1	0.1	98	33.4	33.0	5.0	8	0.0	0.0	0.1	101
211	89/08/28	19.6	16.3	0.2	91	29.1	28.9	4.0	11	0.0	0.0	0.1	101

Table A4.1 Original TDR and gypsum block data with matching volumetric moisture (θ) and head (h) estimates for all sites and dates

		Data for 0-15 cm				Data for 15-40 cm				Data for 40-60 cm			
Site Numb	Date	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp	Raw TDR	TDR (θ)	Gyp (h)	Raw Gyp
211	89/09/05	30.6	25.4	0.1	98	41.0	39.3	0.4	86	0.0	0.0	0.1	102
211	89/09/11	24.7	20.6	0.1	97	32.6	31.0	0.1	96	0.0	0.0	0.1	101
211	89/09/18	19.1	15.9	0.3	88	30.3	30.8	0.1	97	0.0	0.0	0.1	102
211	89/09/26	17.2	14.3	3.0	20	29.8	31.1	0.1	98	0.0	0.0	0.1	101
211	90/04/03	25.4	21.1	0.1	97	30.5	28.0	0.2	91	0.0	0.0	0.6	75
211	90/04/19	18.5	15.4	0.2	95	27.3	27.1	0.3	90	0.0	0.0	0.2	92
211	90/05/15	16.8	14.0	0.7	61	26.1	26.3	0.1	96	0.0	0.0	0.1	101
300	89/06/07	18.4	15.3	0.2	91	31.4	32.6	0.1	96	0.0	0.0	0.1	99
300	89/06/12	20.8	17.3	0.2	95	28.3	27.2	0.2	93	0.0	0.0	0.1	99
300	89/06/19	17.0	14.2	0.6	77	17.1	14.4	0.2	93	0.0	0.0	0.1	100
300	89/06/26	17.3	14.4	0.4	81	31.0	32.6	0.3	88	0.0	0.0	0.1	101
300	89/07/04	16.0	13.3	0.7	61	27.3	28.3	0.2	92	0.0	0.0	0.1	102
300	89/07/10	13.6	11.4	2.0	25	26.4	28.4	0.2	93	0.0	0.0	0.1	102
300	89/07/17	14.3	11.9	3.0	16	26.4	28.1	0.2	94	0.0	0.0	0.1	103
300	89/07/24	9.7	8.1	10.0	4	21.5	23.8	0.2	93	0.0	0.0	0.1	102
300	89/07/31	11.2	9.4	1.5	36	23.7	25.9	0.2	93	0.0	0.0	0.1	102
300	89/08/09	10.8	9.0	3.0	20	26.4	29.8	0.2	93	0.0	0.0	0.1	102
300	89/08/14	10.1	8.5	4.0	14	28.6	33.0	0.2	94	0.0	0.0	0.1	102
300	89/08/22	16.8	14.0	0.2	94	28.9	30.0	0.2	93	0.0	0.0	0.1	102
300	89/08/28	14.3	11.9	0.4	83	28.1	30.3	0.2	91	0.0	0.0	0.1	102
300	89/09/05	24.2	20.1	0.2	95	33.7	32.7	0.1	100	0.0	0.0	0.1	102
300	89/09/11	20.5	17.1	0.1	96	30.3	30.1	0.1	101	0.0	0.0	0.1	102
300	89/09/18	17.2	14.3	0.2	92	27.9	28.5	0.1	101	0.0	0.0	0.1	102
300	89/09/26	15.5	12.9	0.4	82	28.3	29.9	0.1	100	0.0	0.0	0.1	102
300	90/04/03	31.4	26.1	0.2	91	0.0	0.0	0.3	89	0.0	0.0	0.3	88
300	90/04/19	24.7	20.6	0.2	94	30.8	28.6	0.2	95	0.0	0.0	0.1	100
300	90/05/15	17.9	14.9	0.1	97	25.6	25.1	0.1	99	0.0	0.0	0.1	101

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: COR, Day No. 93											
155	93	90/04/03	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
182	93	90/04/03	0.1	34.1	0.0	0.1	36.7	0.0	0.1	45.6	0.0
183	93	90/04/03	0.2	25.9	39.1	10.0	20.8	23.4	5.0	20.0	18.4
184	93	90/04/03	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
189	93	90/04/03	0.1	43.2	0.0	0.1	41.9	0.0	0.1	47.2	0.0
191	93	90/04/03	0.1	38.2	0.0	0.1	44.9	0.0	0.1	0.0	0.0
194	93	90/04/03	0.1	42.4	0.0	0.1	38.4	0.0	0.1	49.8	0.0
203	93	90/04/03	0.1	35.7	0.0	0.1	26.4	0.0	0.6	0.0	0.0
204	93	90/04/03	0.1	20.0	45.7	0.3	34.6	40.5	2.0	31.2	48.8
Subtotal			1.0	239.5	84.8	11.0	243.7	63.9	8.2	193.8	67.2
Mean			0.1	34.2	42.4	1.2	34.8	32.0	0.9	38.8	33.6
Soil Series: COR, Day No. 109											
155	109	90/04/19	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
182	109	90/04/19	0.1	34.1	0.0	0.1	36.7	0.0	0.1	45.6	0.0
183	109	90/04/19	0.2	22.5	22.6	1.5	22.5	25.2	1.0	27.0	28.1
184	109	90/04/19	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
189	109	90/04/19	0.1	43.2	0.0	0.1	41.9	0.0	0.1	47.2	0.0
191	109	90/04/19	0.1	38.2	0.0	0.1	44.9	0.0	0.1	0.0	0.0
194	109	90/04/19	0.1	42.4	0.0	0.1	38.4	0.0	0.1	49.8	0.0
203	109	90/04/19	0.1	0.0	53.5	0.1	47.8	39.3	0.1	0.0	40.5
204	109	90/04/19	0.1	30.8	34.1	0.1	34.2	36.0	0.4	27.5	41.5
Subtotal			1.0	211.2	110.2	2.3	266.4	100.5	2.1	197.1	110.1
Mean			0.1	35.2	36.7	0.3	38.0	33.5	0.2	39.4	36.7
Soil Series: COR, Day No. 158											
155	158	89/06/07	0.2	23.9	35.3	0.1	43.6	43.8	0.1	27.2	35.8
183	158	89/06/07	2.0	10.4	20.0	0.2	20.5	31.7	0.4	31.7	27.7
189	158	89/06/07	0.2	25.4	38.3	0.2	34.4	36.7	0.1	44.5	42.2
191	158	89/06/07	0.2	35.1	38.4	0.1	47.9	25.9	0.2	0.0	41.5
194	158	89/06/07	0.1	2.9	72.8	0.2	55.2	43.8	0.1	49.4	48.6
203	158	89/06/07	0.2	37.3	37.1	0.1	25.5	31.0	0.1	0.0	40.3
204	158	89/06/07	0.6	14.1	28.7	0.1	27.4	32.0	0.2	42.2	27.7
Subtotal			3.5	149.1	270.6	1.0	254.5	244.9	1.2	195.0	263.8
Mean			0.4	21.3	38.7	0.1	36.4	35.0	0.2	39.0	37.7

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: COR, Day No. 185											
155	185	89/07/04	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
182	185	89/07/04	0.1	34.1	0.0	0.1	36.7	0.0	0.1	45.6	0.0
183	185	89/07/04	0.1	23.5	14.3	0.8	24.6	24.6	1.5	39.2	14.7
184	185	89/07/04	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
189	185	89/07/04	0.1	43.2	0.0	0.1	41.9	0.0	0.1	47.2	0.0
191	185	89/07/04	0.1	38.2	0.0	0.1	44.9	0.0	0.1	0.0	0.0
194	185	89/07/04	0.2	43.7	40.8	0.2	33.5	28.8	0.2	50.8	39.7
203	185	89/07/04	0.1	39.0	38.3	0.1	24.4	35.7	0.1	0.0	37.0
204	185	89/07/04	0.2	23.2	21.7	0.4	32.8	26.5	0.1	25.0	20.7
Subtotal			1.1	244.9	115.1	2.0	238.8	115.6	2.4	207.8	112.1
Mean			0.1	35.0	28.8	0.2	34.1	28.9	0.3	41.6	28.0
Soil Series: COR, Day No. 212											
155	212	89/07/31	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
182	212	89/07/31	0.1	34.1	0.0	0.2	36.7	0.0	0.2	45.6	0.0
183	212	89/07/31	10.0	13.3	13.8	2.0	20.7	22.8	1.0	31.7	22.6
184	212	89/07/31	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
189	212	89/07/31	0.1	43.2	0.0	0.1	41.9	0.0	0.2	47.2	0.0
191	212	89/07/31	0.1	38.2	0.0	0.1	44.9	0.0	0.1	0.0	0.0
194	212	89/07/31	0.1	42.4	0.0	0.1	38.4	0.0	0.2	49.8	0.0
203	212	89/07/31	0.1	34.8	28.4	0.1	27.0	32.0	0.1	0.0	34.9
204	212	89/07/31	1.5	14.3	11.8	1.5	27.3	21.6	0.1	42.5	19.6
Subtotal			12.2	220.3	54.0	4.3	236.9	76.4	2.1	216.8	77.1
Mean			1.3	31.5	18.0	0.5	33.8	25.5	0.2	43.4	25.7
Soil Series: COR, Day No. 240											
155	240	89/08/28	0.1	38.4	45.2	0.1	48.0	45.9	0.1	29.4	37.2
182	240	89/08/28	0.2	23.2	23.1	0.2	26.7	31.2	0.1	59.0	35.8
183	240	89/08/28	0.2	17.1	10.0	4.0	29.6	15.0	1.5	20.7	18.9
184	240	89/08/28	0.1	30.2	0.0	0.1	40.4	0.0	0.1	52.5	0.0
189	240	89/08/28	0.1	38.4	50.7	0.1	44.0	35.7	0.1	41.9	39.4
191	240	89/08/28	0.1	34.8	24.9	0.1	47.0	27.9	0.1	0.0	33.0
194	240	89/08/28	0.2	28.3	41.8	0.2	39.5	32.5	0.2	53.9	37.0
203	240	89/08/28	0.3	26.4	18.8	0.4	32.0	24.8	0.1	0.0	31.8
204	240	89/08/28	0.6	15.3	19.4	1.0	33.9	27.2	0.1	41.6	22.4
Subtotal			1.9	252.1	233.9	6.2	341.1	240.2	2.4	299.0	255.5
Mean			0.2	28.0	29.2	0.7	37.9	30.0	0.2	42.7	31.9

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: COR, Day No. 269											
155	269	89/09/26	0.1	32.3	38.5	0.1	44.9	40.2	0.1	27.9	35.5
182	269	89/09/26	0.4	28.0	31.9	0.1	35.2	31.8	0.1	37.3	38.9
183	269	89/09/26	0.3	17.1	16.2	0.2	23.5	13.0	0.1	0.0	14.1
184	269	89/09/26	0.2	17.1	18.8	0.2	27.5	35.6	0.2	52.1	40.9
189	269	89/09/26	0.3	35.1	48.0	0.1	37.5	36.7	0.1	47.4	47.8
191	269	89/09/26	0.1	32.3	32.9	0.1	31.7	24.8	0.1	0.0	37.5
194	269	89/09/26	0.1	25.0	30.4	0.1	39.6	39.0	0.2	42.2	44.5
203	269	89/09/26	0.2	27.0	32.0	0.3	28.4	32.2	0.1	0.0	33.5
204	269	89/09/26	0.4	18.0	18.6	0.8	28.9	32.4	0.1	33.8	26.3
Subtotal			2.1	231.9	267.3	2.0	297.2	285.7	1.1	240.7	319.0
Mean			0.2	25.8	29.7	0.2	33.0	31.7	0.1	40.1	35.4
Soil Series: DYD, Day No. 93											
176	93	90/04/03	0.1	29.8	26.9	0.3	0.0	27.7	0.4	0.0	25.2
177	93	90/04/03	0.2	22.5	27.4	7.0	20.3	24.1	7.0	2.8	19.3
190	93	90/04/03	0.2	25.0	32.0	0.6	24.7	28.7	0.7	34.4	17.9
211	93	90/04/03	0.1	21.1	23.4	0.2	28.0	21.8	0.6	0.0	24.8
300	93	90/04/03	0.2	26.1	28.6	0.3	0.0	18.9	0.3	0.0	33.0
Subtotal			0.8	124.5	138.3	8.4	73.0	121.2	9.0	37.2	120.2
Mean			0.2	24.9	27.6	1.7	24.3	24.2	1.8	18.6	24.0
Soil Series: DYD, Day No. 109											
176	109	90/04/19	0.1	22.1	22.5	0.1	0.0	20.7	0.2	0.0	24.9
177	109	90/04/19	0.2	19.1	23.3	0.2	22.6	21.6	3.0	9.9	16.2
190	109	90/04/19	0.2	21.1	29.2	0.1	23.0	28.3	0.2	39.7	33.0
211	109	90/04/19	0.2	15.4	15.7	0.3	27.1	30.5	0.2	0.0	34.9
300	109	90/04/19	0.2	20.6	21.4	0.2	28.6	22.2	0.1	0.0	23.1
Subtotal			0.9	98.3	112.1	0.9	101.3	123.3	3.7	49.6	132.1
Mean			0.2	19.7	22.4	0.2	20.3	24.7	0.7	24.8	26.4
Soil Series: DYD, Day No. 158											
176	158	89/06/07	0.1	24.0	21.6	0.1	0.0	19.3	0.1	0.0	24.2
177	158	89/06/07	0.2	17.2	19.0	0.2	20.1	21.2	0.6	13.0	18.1
190	158	89/06/07	0.2	22.9	28.2	0.7	25.3	31.7	0.6	29.5	27.4
211	158	89/06/07	0.7	13.3	18.0	0.4	17.5	30.0	0.1	0.0	34.7
300	158	89/06/07	0.2	15.3	17.7	0.1	32.6	20.5	0.1	0.0	23.8
Subtotal			1.4	92.7	104.5	1.5	95.5	122.7	1.5	42.5	128.2
Mean			0.3	18.5	20.9	0.3	23.9	24.5	0.3	21.3	25.6

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: DYD, Day No. 185											
176	185	89/07/04	0.1	29.8	20.7	0.1	0.0	20.7	0.1	0.0	18.1
177	185	89/07/04	0.1	20.4	19.8	0.2	23.0	19.3	1.5	23.5	12.9
190	185	89/07/04	0.1	31.7	27.8	0.1	33.0	28.2	0.4	24.7	25.6
211	185	89/07/04	0.1	16.3	16.4	0.7	30.9	31.2	0.1	0.0	33.3
300	185	89/07/04	0.7	13.3	12.2	0.2	28.3	15.2	0.1	0.0	22.1
Subtotal			1.1	111.5	96.9	1.3	115.2	114.6	2.2	48.2	112.0
Mean			0.2	22.3	19.4	0.3	28.8	22.9	0.4	24.1	22.4
Soil Series: DYD, Day No. 212											
176	212	89/07/31	2.0	23.5	16.9	0.1	0.0	28.0	0.1	0.0	20.4
177	212	89/07/31	2.0	16.3	11.4	0.2	20.8	12.0	0.3	20.6	10.6
190	212	89/07/31	0.1	28.0	23.9	0.1	25.4	22.5	0.2	36.9	17.0
211	212	89/07/31	4.0	12.3	11.0	5.0	32.5	20.2	0.1	0.0	25.6
300	212	89/07/31	1.5	9.4	7.1	0.2	25.9	13.3	0.1	0.0	20.5
Subtotal			9.6	89.5	70.3	5.6	104.6	96.0	0.8	57.5	94.1
Mean			1.9	17.9	14.0	1.1	20.9	19.2	0.2	28.8	18.8
Soil Series: DYD, Day No. 240											
176	240	89/08/28	0.8	24.9	16.2	0.1	0.0	18.3	0.1	0.0	20.4
177	240	89/08/28	0.2	18.4	18.4	0.2	24.2	17.3	0.3	13.6	18.3
190	240	89/08/28	0.1	28.3	17.8	0.1	27.8	9.1	0.1	33.7	17.0
211	240	89/08/28	0.2	16.3	13.8	4.0	28.9	16.6	0.1	0.0	23.7
300	240	89/08/28	0.4	11.9	10.6	0.2	30.3	3.4	0.1	0.0	22.1
Subtotal			1.7	99.8	76.8	4.6	111.2	64.7	0.7	47.3	101.5
Mean			0.3	25.0	15.4	0.9	27.8	12.9	0.1	23.7	20.3
Soil Series: DYD, Day No. 269											
176	269	89/09/26	0.1	28.0	22.1	0.1	0.0	18.5	0.1	0.0	20.1
177	269	89/09/26	0.1	20.5	20.5	0.1	25.3	23.5	0.2	14.2	22.3
190	269	89/09/26	0.2	26.4	30.8	0.1	27.2	33.2	0.1	35.9	22.1
211	269	89/09/26	3.0	14.3	19.0	0.1	31.1	24.2	0.1	0.0	33.3
300	269	89/09/26	0.4	12.9	13.9	0.1	29.9	16.2	0.1	0.0	24.4
Subtotal			3.8	102.1	106.3	0.5	113.5	115.6	0.6	50.1	122.2
Mean			0.8	20.4	21.3	0.1	28.4	23.1	0.1	25.0	24.4
Soil Series: EOR, Day No. 93											
175	93	90/04/03	0.2	20.6	20.1	4.0	22.8	22.5	3.0	12.4	19.0
188	93	90/04/03	15.0	18.0	24.0	0.2	22.6	18.0	0.6	0.0	19.6
193	93	90/04/03	0.2	19.1	25.2	4.0	21.5	27.5	0.7	17.6	13.8
207	93	90/04/03	0.3	22.5	24.1	3.0	28.3	27.8	5.0	22.8	21.1
Subtotal			15.7	80.2	93.4	11.2	95.2	95.8	9.3	52.8	73.5
Mean			3.9	20.1	23.4	2.8	23.8	23.9	2.3	13.2	18.4

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: EOR, Day No. 109											
175	109	90/04/19	0.2	18.4	17.7	0.7	24.3	17.5	1.5	17.0	13.9
188	109	90/04/19	15.0	12.9	18.9	0.1	22.7	20.9	0.1	47.8	13.8
193	109	90/04/19	0.2	18.0	24.4	0.2	20.4	19.8	0.4	20.7	12.8
207	109	90/04/19	0.8	15.3	18.3	0.3	29.7	23.2	4.0	33.6	18.3
Subtotal			16.2	64.6	79.3	1.3	97.1	81.4	6.0	119.1	58.8
Mean			4.1	16.2	19.8	0.4	24.3	20.4	1.5	29.8	14.7
Soil Series: EOR, Day No. 158											
175	158	89/06/07	1.5	15.3	15.3	1.5	24.3	17.6	0.4	17.0	14.2
188	158	89/06/07	0.8	15.9	17.6	0.2	20.9	20.0	0.1	0.0	15.9
193	158	89/06/07	0.2	21.1	21.8	2.0	13.3	23.0	0.1	28.2	13.2
207	158	89/06/07	1.0	18.0	18.6	0.2	31.0	24.0	0.7	24.0	16.8
Subtotal			3.5	70.3	73.3	3.9	89.5	84.6	1.3	69.2	60.1
Mean			0.9	17.6	18.3	1.0	22.4	21.2	0.3	17.3	15.0
Soil Series: EOR, Day No. 185											
175	185	89/07/04	0.1	21.5	19.0	1.5	23.7	23.1	0.4	37.9	13.9
188	185	89/07/04	0.2	17.3	13.5	0.6	21.9	12.9	0.1	0.0	13.8
193	185	89/07/04	0.1	22.1	21.7	0.6	21.9	19.8	0.1	27.1	11.4
207	185	89/07/04	0.7	20.6	16.5	0.2	32.4	21.0	0.7	31.3	16.3
Subtotal			1.1	81.5	70.7	2.9	99.9	76.8	1.3	96.3	55.4
Mean			0.3	20.4	17.7	0.7	25.0	19.2	0.3	24.1	13.8
Soil Series: EOR, Day No. 212											
175	212	89/07/31	1.0	20.1	10.1	1.5	27.6	16.7	0.3	20.6	17.4
188	212	89/07/31	7.0	13.3	8.4	1.0	21.9	10.1	0.1	0.0	11.9
193	212	89/07/31	0.1	21.1	18.5	0.1	22.7	21.5	0.1	21.8	22.0
207	212	89/07/31	4.0	17.1	8.6	0.2	28.0	11.4	0.4	33.2	12.6
Subtotal			12.1	71.6	45.6	2.8	100.2	59.7	0.9	75.6	63.9
Mean			3.0	17.9	11.4	0.7	25.0	14.9	0.2	18.9	15.9
Soil Series: EOR, Day No. 240											
175	240	89/08/28	0.1	27.4	16.7	1.5	31.4	14.6	1.5	22.4	16.4
188	240	89/08/28	0.1	17.1	14.1	2.0	22.1	14.4	0.1	0.0	16.6
193	240	89/08/28	0.1	19.5	17.4	0.1	25.4	14.7	0.1	23.8	9.0
207	240	89/08/28	1.0	20.1	14.2	0.2	31.8	12.9	0.4	39.1	15.7
Subtotal			1.3	84.1	62.4	3.8	110.7	56.6	2.1	85.3	57.7
Mean			0.3	21.0	15.6	1.0	27.7	14.2	0.5	21.3	14.4

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: EOR, Day No. 269											
175	269	89/09/26	0.8	18.4	20.8	0.7	23.7	24.6	0.4	19.9	21.6
188	269	89/09/26	0.2	22.5	25.2	4.0	25.5	20.9	1.5	23.2	18.6
193	269	89/09/26	0.1	20.1	25.1	0.1	23.9	23.5	0.1	22.2	20.1
207	269	89/09/26	1.5	15.3	15.2	0.2	31.5	22.5	0.2	31.7	18.9
Subtotal			2.6	76.3	86.3	5.0	104.6	91.5	2.2	97.0	79.2
Mean			0.7	19.0	21.6	1.3	26.2	22.9	0.6	24.3	19.8
Soil-Series:-FMN, Day No. 93											
192	93	90/04/03	0.1	78.4	38.1	0.1	0.0	34.0	0.3	0.0	42.4
200	93	90/04/03	0.1	33.6	48.5	0.1	53.0	37.8	0.1	0.0	40.8
201	93	90/04/03	0.2	28.0	40.6	0.7	49.6	26.2	0.4	0.0	33.0
202	93	90/04/03	0.3	40.3	68.9	2.0	34.9	38.5	0.2	22.5	29.0
Subtotal			0.7	180.3	196.1	2.9	137.5	136.5	1.0	22.5	145.2
Mean			0.2	45.1	49.0	0.7	45.8	34.1	0.3	22.5	36.3
Soil-Series: FMN, Day No. 109											
192	109	90/04/19	0.1	54.1	29.6	0.1	0.0	43.3	0.2	0.0	38.2
200	109	90/04/19	0.1	29.8	30.0	0.1	49.2	36.0	0.1	0.0	40.8
201	109	90/04/19	0.1	24.5	0.0	0.7	52.5	67.8	0.1	0.0	35.5
202	109	90/04/19	0.2	38.4	41.8	0.2	38.1	32.4	0.2	35.8	27.5
Subtotal			0.5	146.8	101.4	1.1	139.8	179.5	0.6	35.8	142.0
Mean			0.1	36.7	33.8	0.3	46.6	44.8	0.2	35.8	35.5
Soil-Series: FMN, Day No. 158											
192	158	89/06/07	0.1	13.5	34.5	0.1	0.0	32.8	0.1	0.0	40.0
200	158	89/06/07	0.8	21.6	32.8	0.2	60.2	30.7	0.1	0.0	38.4
201	158	89/06/07	4.0	9.4	13.1	0.2	37.7	29.7	0.1	0.0	34.4
202	158	89/06/07	3.0	23.5	25.2	0.1	37.9	21.3	0.2	34.6	21.1
Subtotal			7.9	68.0	105.6	0.6	135.8	114.5	0.5	34.6	133.9
Mean			2.0	17.0	26.4	0.2	45.3	28.6	0.1	34.6	33.5
Soil-Series: FMN, Day No. 185											
192	185	89/07/04	0.1	78.8	32.9	0.1	0.0	36.2	0.1	0.0	37.3
200	185	89/07/04	0.1	29.3	22.3	0.1	55.5	26.0	0.1	0.0	27.6
201	185	89/07/04	0.1	26.4	20.5	0.1	50.6	26.8	0.1	0.0	26.7
202	185	89/07/04	0.2	31.9	30.8	0.2	31.6	24.6	0.2	36.2	20.5
Subtotal			0.5	166.4	106.5	0.5	137.7	113.6	0.5	36.2	112.1
Mean			0.1	41.6	26.6	0.1	45.9	28.4	0.1	36.2	28.0

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil-Series: FMN, Day No. 212											
192	212	89/07/31	0.1	78.8	31.6	0.1	0.0	36.3	0.1	0.0	35.5
200	212	89/07/31	5.0	14.3	11.4	0.1	64.5	27.8	0.1	0.0	34.5
201	212	89/07/31	7.0	11.9	9.8	0.1	46.0	21.6	0.1	0.0	24.2
202	212	89/07/31	10.0	27.4	17.4	0.4	31.1	19.2	0.1	40.2	19.2
Subtotal			22.1	132.4	70.2	0.7	141.6	104.9	0.4	40.2	113.4
Mean			5.5	33.1	17.5	0.2	47.2	26.2	0.1	40.2	28.4
Soil-Series: FMN, Day No. 240											
192	240	89/08/28	0.1	82.0	25.5	0.1	0.0	32.8	0.1	0.0	37.6
200	240	89/08/28	5.0	14.9	11.6	0.1	64.2	30.2	0.1	0.0	34.5
201	240	89/08/28	10.0	11.9	11.3	0.3	46.0	22.2	0.1	0.0	26.2
202	240	89/08/28	4.0	26.1	19.1	5.0	35.9	15.9	0.1	35.2	14.1
Subtotal			19.1	134.9	67.5	5.5	146.1	101.1	0.4	35.2	112.4
Mean			4.8	33.7	16.9	1.4	36.5	25.3	0.1	35.2	28.1
Soil-Series: FMN, Day No. 269											
192	269	89/09/26	0.1	50.6	29.6	0.1	0.0	36.0	0.1	0.0	39.2
200	269	89/09/26	15.0	12.6	16.6	0.1	65.6	27.1	0.1	0.0	37.8
201	269	89/09/26	15.0	12.3	21.2	0.4	45.7	21.6	0.1	0.0	25.9
202	269	89/09/26	5.0	27.4	27.4	0.6	32.0	23.2	0.1	33.9	20.5
Subtotal			35.1	102.9	94.8	1.2	143.3	107.9	0.4	33.9	123.4
Mean			8.8	25.7	23.7	0.3	47.8	27.0	0.1	33.9	30.9
Soil Series: KLM, Day No. 93											
154	93	90/04/03	0.2	17.3	35.1	5.0	35.5	21.5	0.1	42.2	22.7
179	93	90/04/03	0.3	27.4	27.9	3.0	22.3	27.0	0.1	0.0	31.9
180	93	90/04/03	0.1	37.8	37.3	0.1	0.0	37.7	0.1	0.0	42.3
181	93	90/04/03	0.1	35.3	66.6	0.1	0.0	42.7	4.0	0.0	47.4
200	93	90/04/03	0.1	33.6	48.5	0.1	53.0	37.8	0.1	0.0	40.8
205	93	90/04/03	0.1	31.6	43.1	0.6	27.3	25.3	1.5	19.6	19.0
Subtotal			0.9	183.0	258.5	8.9	138.1	192.0	5.9	61.8	204.1
Mean			0.2	30.5	43.1	1.5	34.5	32.0	1.0	30.9	34.0
Soil Series: KLM, Day No. 109											
154	109	90/04/19	0.2	14.9	22.1	2.0	16.7	22.0	0.1	0.0	22.2
179	109	90/04/19	0.2	21.1	29.9	0.8	25.7	20.7	0.1	0.0	29.0
180	109	90/04/19	0.1	36.7	33.4	0.1	0.0	43.5	0.1	0.0	42.8
181	109	90/04/19	0.1	32.7	36.6	0.1	0.0	41.0	0.1	0.0	42.2
200	109	90/04/19	0.1	29.8	30.0	0.1	49.2	36.0	0.1	0.0	40.8
205	109	90/04/19	0.7	23.5	28.4	0.2	25.6	17.7	0.8	0.0	23.4
Subtotal			1.4	158.7	180.4	3.3	117.2	180.9	1.3	0.0	200.4
Mean			0.2	26.5	30.0	0.6	29.3	30.2	0.2	0.0	33.4

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: KLM, Day No. 158											
154	158	89/06/07	7.0	5.6	11.1	1.5	11.4	17.7	0.1	0.0	25.3
179	158	89/06/07	0.7	11.9	12.4	0.2	27.1	20.6	0.1	0.0	30.4
180	158	89/06/07	0.2	27.2	23.2	0.1	0.0	38.5	0.1	0.0	37.6
181	158	89/06/07	2.0	17.1	18.2	0.1	0.0	38.9	0.1	0.0	33.0
200	158	89/06/07	0.8	21.6	32.8	0.2	60.2	30.7	0.1	0.0	38.4
205	158	89/06/07	0.7	19.5	30.5	1.0	32.0	20.0	0.1	0.0	23.0
Subtotal			11.4	102.9	128.2	3.1	130.7	166.4	0.6	0.0	187.7
Mean			1.9	17.2	21.4	0.5	32.7	27.7	0.1	0.0	31.3
Soil Series: KLM, Day No. 185											
154	185	89/07/04	2.0	11.4	27.9	3.0	12.2	26.7	0.1	0.0	18.9
179	185	89/07/04	0.1	27.4	25.7	0.1	34.6	21.0	0.1	0.0	20.8
180	185	89/07/04	0.1	75.1	36.2	0.1	0.0	40.0	0.1	0.0	43.5
181	185	89/07/04	0.1	31.2	31.5	0.1	0.0	35.1	0.1	0.0	36.6
200	185	89/07/04	0.1	29.3	22.3	0.1	55.5	26.0	0.1	0.0	27.6
205	185	89/07/04	0.1	27.4	27.5	1.0	33.0	15.0	0.1	0.0	19.4
Subtotal			2.5	201.8	171.1	4.4	135.3	163.8	0.6	0.0	166.8
Mean			0.4	33.6	28.5	0.7	33.8	27.3	0.1	0.0	27.8
Soil Series: KLM, Day No. 212											
154	212	89/07/31	10.0	7.1	13.3	2.0	14.8	19.9	0.1	0.0	22.1
179	212	89/07/31	0.4	18.4	18.4	0.1	27.7	17.3	0.1	0.0	26.0
180	212	89/07/31	0.6	27.4	19.7	0.1	0.0	37.1	0.1	0.0	36.1
181	212	89/07/31	5.0	15.3	12.2	0.1	0.0	38.0	0.1	0.0	40.8
200	212	89/07/31	5.0	14.3	11.4	0.1	64.5	27.8	0.1	0.0	34.5
205	212	89/07/31	2.0	21.6	18.6	0.1	29.8	15.8	0.1	0.0	16.6
Subtotal			23.0	104.1	93.6	2.5	136.8	155.9	0.6	0.0	176.1
Mean			3.8	17.4	15.6	0.4	34.2	30.0	0.1	0.0	29.4
Soil Series: KLM, Day No. 240											
154	240	89/08/28	7.0	10.0	16.2	2.0	13.4	18.8	0.1	0.0	20.8
179	240	89/08/28	0.3	21.1	26.1	0.1	29.1	17.5	0.1	0.0	27.3
180	240	89/08/28	0.6	33.2	25.0	0.1	0.0	34.0	0.2	0.0	39.9
181	240	89/08/28	4.0	15.3	32.5	0.1	0.0	35.7	0.1	0.0	34.9
200	240	89/08/28	5.0	14.9	11.6	0.1	64.2	30.2	0.1	0.0	34.5
205	240	89/08/28	0.6	23.5	21.1	0.2	33.6	12.6	0.1	0.0	17.8
Subtotal			17.5	118.0	132.5	2.6	140.3	148.8	0.7	0.0	175.2
Mean			2.9	19.7	22.1	0.4	35.1	24.8	0.1	0.0	29.2

Table A4.2 Comparison of volumetric soil moisture as determined by TDR and gravimetric sampling by Soil Series and by date.

Site No.	Day No	Date	Gyp 15h	TDR 15	Gvol 15	Gyp 40h	TDR 40	Gvol 40	Gyp 60h	TDR 60	Gvol 60
Soil Series: KLM, Day No. 269											
154	269	89/09/26	0.3	14.0	22.0	2.0	15.6	18.0	0.1	0.0	19.7
179	269	89/09/26	0.2	23.2	24.7	0.1	30.1	32.2	0.1	0.0	28.2
180	269	89/09/26	0.2	30.1	28.0	0.1	0.0	37.8	0.1	0.0	42.5
181	269	89/09/26	7.0	15.3	12.1	0.1	0.0	40.3	0.1	0.0	48.8
200	269	89/09/26	15.0	12.6	16.6	0.1	65.6	27.1	0.1	0.0	37.8
205	269	89/09/26	0.8	25.4	23.3	0.1	28.9	18.9	0.1	0.0	24.0
Subtotal			23.5	120.6	126.7	2.5	140.2	174.3	0.6	0.0	201.0
Mean			3.9	20.1	21.1	0.4	35.1	29.1	0.1	0.0	33.5

APPENDIX 5

METEOROLOGICAL DATA

RECORDED AT THE LUNTY SITE

A5.1 Introduction

This appendix contains all meteorological data recorded at the Lunty site. Hourly data are provided for the variables precipitation, global radiation, mean air temperature, relative humidity, wind speed and estimated cloud cover fraction. The complete data set of hourly observations is listed (Table A5.1) for the period from March 22, 1989 to June 15, 1989. These date provide the basis for input to the simulation model described in Chapters 5 & 6.

The hourly meteorological data are summarized and illustrated (Figures A5.1 to A5.12) for each of the 12 weeks from March 22 to June 15, 1989. The graphs clearly illustrate the strong relationships among global solar radiation, air temperature and relative humidity. The data are summarized and analysed below.

Temperature increases with increasing solar radiation and drops with lower solar radiation. There is a lag of 1 to 2 hours between changes in solar radiation and air temperature. The estimate of cloud cover is clearly based on the reciprical of solar radiation. The effect of using a linear interpolation between last evening cloud estimate and first morning cloud estimate to estimate night time cloud cover is apparent in the straight lines and blocky appearance of the cloud cover graphs. Dispite the blocky appearance, the cloud cover estimates appear reasonable with low cloud cover estimated for bright sunny days and high cloud cover for cooler days with less than maximum solar radiation. Wind speed is less strongly related to the other variables but does show a pattern of increasing during the day and diminishing at night. High wind speeds occur during periods of bright sunshine (when they are reflected in lower temperatures) and during periods of low radiation and low temperature (clouds and rain).

Initial temperatures were mainly well below zero with only the odd mid day temperature above zero until March 30 when daytime temperatures were consistently above zero and night time temperatures fell to just above zero. There was a consistent trend to warmer temperatures from March 30 onward which was interupted by cold periods on April 7&8, April 16, April 24&25 and May 19,23 and 24. Daytime highs were from 10 to 20° C in

April, 15 to 30° C in May and 20 to 30° C in June. Night time lows reached 0° C most nights in April, were 0 to 10 ° C most nights in May and ranged from 5 to 15° C in June. Temperatures conducive to the onset of spring melt began on March 29 and continued through to April 6.

The solar radiation graphs (Figures A5.1 to A5.12) indicate that bright sunny conditions conducive to snowmelt and runoff existed from March 29 through to April 23 with only limited cloudiness on April 3, 5, 10, 12 and 19. Maximum solar radiation ranged from 700 to 800 W m^{-2} in all months. Drops in solar radiation were directly reflected by parallel drops in air temperature.

The graphs (Figures A5.1 to A5.12) illustrate the strong and consistent dirunal fluxuation in relative humidity. Relative humiidity was consistently high (80-90%) during the night and fell to 20 to 50% during the day. The degree of drop in relative humidity was a function of both solar radiation and air temperature. High day time temperatures and high solar radiation decreased the relative humidity. Relative humidity recovered to near 100% during the cooler night time periods. High relative humidity during the day time was associated with lower temperatures, lower solar radiation and higher (inferred) cloud cover. The relative humidity data indicate that evaporation would be most likely to occur during the main daylight hours and would be unlikely to occur during the night when relative humidities were high and wind speeds were lowest.

Wind speeds ranged from 0 to a maximum of 12 m sec^{-1} (Figures A6.1 to A6.12). Wind speed dropped to 0 at some point in most nights. There was only moderate wind during the main period of spring melt from March 29 to April 6. Most of the remaining days in April, May and June were quite windy with maximum day time wind speeds in excess of 6 m sec^{-1}.

Daily rainfall at the Lunty site (Table A5.2) was very low during the period of spring runoff from April 1 until June 15. The only significant spring runoff rainfall events occurred on May 19 and June 9 to 15. The first period of sustained heavy precipitation occurred in late June and early July (June 21 to July 4). A second period of heavy precipitation occurred between July 11 and July 27 and another between August 16 and September 5. There were 2 rainfall events in October (October 15 and 30). The low amount of rainfall during the April to June period suggests that most of the runoff that occurred during the spring months resulted from rapid snowmelt rather than rainfall excess runoff.

Pan evaporation readings taken at approximately weekly intervals are listed in Table A5.3. Readings were taken at shorter intervals during periods of heavy rainfall so as to permit the removal of excess rainwater from the pan. Total rainfall was computed to correspond with each interval for which pan evaporation data applied. Pan evaporation exceeded rainfall by a considerable margin for all intervals. Rainfall never exceeded pan evaporation for any recorded period. Total cumulative pan evaporation (1120 mm) was more than three times the total rainfall (273.9 mm) for the period from April 1 to October 31. These data confirm the net moisture deficit at the site and illustrate that an excess of precipitation over evaporation never persists for significant periods. Any excess of rainfall over evaporation can only be expected to occur for short periods during actual heavy rainfall events.

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
81	March	22	16	0.00	322.00	-2.6	0.78	3.06	0.44
81	March	22	17	0.00	260.00	-2.1	0.78	3.61	0.45
81	March	22	18	0.00	212.00	-1.8	0.79	4.72	0.46
81	March	22	19	0.00	94.00	-1.9	0.80	3.89	0.47
81	March	22	20	0.00	13.00	-2.6	0.83	3.61	0.48
81	March	22	21	0.00	0.00	-3.0	0.85	3.06	0.49
81	March	22	22	0.00	0.00	-3.8	0.87	3.61	0.50
81	March	22	23	0.00	0.00	-3.9	0.88	3.61	0.51
81	March	22	24	0.00	0.00	-4.4	0.88	3.61	0.52
82	March	23	1	0.00	0.00	-5.0	0.89	3.06	0.53
82	March	23	2	0.00	0.00	-5.8	0.89	2.78	0.54
82	March	23	3	0.00	0.00	-6.4	0.90	2.78	0.55
82	March	23	4	0.00	0.00	-6.5	0.91	2.78	0.56
82	March	23	5	0.00	0.00	-7.0	0.90	2.78	0.57
82	March	23	6	0.00	0.00	-7.0	0.91	2.22	0.58
82	March	23	7	0.00	0.00	-7.5	0.91	1.94	0.59
82	March	23	8	0.00	10.00	-8.1	0.90	2.78	0.60
82	March	23	9	0.00	109.00	-8.0	0.90	1.39	0.61
82	March	23	10	0.00	172.00	-5.6	0.92	1.39	0.61
82	March	23	11	0.00	366.00	-4.0	0.90	1.11	0.36
82	March	23	12	0.00	562.00	-0.9	0.78	0.83	0.13
82	March	23	13	0.00	626.00	0.9	0.69	1.94	0.08
82	March	23	14	0.00	657.00	2.0	0.63	1.94	0.03
82	March	23	15	0.00	627.00	3.3	0.58	1.94	0.03
82	March	23	16	0.00	556.00	4.2	0.56	2.78	0.03
82	March	23	17	0.00	445.00	4.5	0.52	2.78	0.05
82	March	23	18	0.00	287.00	4.1	0.53	3.06	0.08
82	March	23	19	0.00	124.00	3.4	0.55	2.22	0.11
82	March	23	20	0.00	16.00	1.5	0.61	1.94	0.13
82	March	23	21	0.00	0.00	0.3	0.64	2.50	0.16
82	March	23	22	0.00	0.00	-0.6	0.66	1.39	0.19
82	March	23	23	0.00	0.00	-1.1	0.67	1.67	0.22
82	March	23	24	0.00	0.00	-1.7	0.71	1.67	0.24
83	March	24	1	0.00	0.00	-1.4	0.70	1.67	0.27
83	March	24	2	0.00	0.00	-1.8	0.72	0.56	0.30
83	March	24	3	0.00	0.00	-2.2	0.80	0.28	0.33
83	March	24	4	0.00	0.00	-2.0	0.82	0.28	0.35
83	March	24	5	0.00	0.00	-1.3	0.76	0.83	0.38
83	March	24	6	0.00	0.00	-1.8	0.78	0.28	0.41
83	March	24	7	0.00	0.00	-2.9	0.79	0.00	0.43
83	March	24	8	0.00	18.00	-3.4	0.84	0.00	0.46
83	March	24	9	0.00	169.00	-2.4	0.81	0.00	0.49
83	March	24	10	0.00	316.00	-0.9	0.74	0.56	0.33
83	March	24	11	0.00	457.00	0.5	0.72	1.67	0.21
83	March	24	12	0.00	567.00	1.2	0.70	1.94	0.12

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
83	March	24	13	0.00	636.00	2.3	0.67	2.50	0.06
83	March	24	14	0.00	661.00	2.4	0.66	2.78	0.03
83	March	24	15	0.00	632.00	3.4	0.66	3.61	0.02
83	March	24	16	0.00	544.00	3.7	0.60	3.06	0.05
83	March	24	17	0.00	416.00	4.2	0.63	2.78	0.12
83	March	24	18	0.00	241.00	3.5	0.67	2.50	0.16
83	March	24	19	0.00	121.00	2.3	0.73	1.94	0.20
83	March	24	20	0.00	18.00	0.8	0.82	1.94	0.23
83	March	24	21	0.00	0.00	0.3	0.85	2.50	0.27
83	March	24	22	0.00	0.00	-0.1	0.84	2.50	0.31
83	March	24	23	0.00	0.00	-0.7	0.84	2.78	0.34
83	March	24	24	0.00	0.00	-1.3	0.83	2.50	0.38
84	March	25	1	0.00	0.00	-1.3	0.81	2.22	0.42
84	March	25	2	0.00	0.00	-2.0	0.85	2.78	0.46
84	March	25	3	0.00	0.00	-3.0	0.88	3.06	0.49
84	March	25	4	0.00	0.00	-3.5	0.89	3.33	0.53
84	March	25	5	0.00	0.00	-4.2	0.91	3.89	0.57
84	March	25	6	0.00	0.00	-4.1	0.94	3.89	0.61
84	March	25	7	0.00	4.00	-3.8	0.94	3.89	0.65
84	March	25	8	0.00	16.00	-3.9	0.94	4.44	0.68
84	March	25	9	0.00	77.00	-3.4	0.95	3.89	0.72
84	March	25	10	0.00	167.00	-2.8	0.95	4.17	0.62
84	March	25	11	0.00	231.00	-2.5	0.94	5.00	0.60
84	March	25	12	0.00	289.00	-2.0	0.93	5.28	0.55
84	March	25	13	0.00	333.00	-1.9	0.91	5.28	0.51
84	March	25	14	0.00	305.00	-1.7	0.89	5.00	0.55
84	March	25	15	0.00	291.00	-1.2	0.89	5.00	0.55
84	March	25	16	0.00	168.00	-1.0	0.88	5.00	0.71
84	March	25	17	0.00	94.00	-1.3	0.90	4.17	0.80
84	March	25	18	0.00	55.00	-1.6	0.91	3.61	0.80
84	March	25	19	0.00	34.00	-1.7	0.92	3.33	0.80
84	March	25	20	0.00	9.00	-1.4	0.92	2.78	0.80
84	March	25	21	0.00	0.00	-1.5	0.94	2.50	0.81
84	March	25	22	0.00	0.00	-1.2	0.93	1.39	0.81
84	March	25	23	0.00	0.00	-1.2	0.92	0.00	0.81
84	March	25	24	0.00	0.00	-1.3	0.93	0.28	0.81
85	March	26	1	0.00	0.00	-1.5	0.94	1.39	0.81
85	March	26	2	0.00	0.00	-1.6	0.95	2.22	0.81
85	March	26	3	0.00	0.00	-1.7	0.95	2.22	0.81
85	March	26	4	0.00	0.00	-1.9	0.95	2.50	0.81
85	March	26	5	0.00	0.00	-2.3	0.95	1.94	0.81
85	March	26	6	0.00	0.00	-2.3	0.95	2.50	0.82
85	March	26	7	0.00	5.00	-2.8	0.95	2.78	0.82
85	March	26	8	0.00	12.00	-3.7	0.94	3.61	0.82
85	March	26	9	0.00	49.00	-3.8	0.93	3.06	0.82

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
85	March	26	10	0.00	101.00	-3.5	0.92	2.50	0.77
85	March	26	11	0.00	153.00	-3.2	0.88	2.22	0.73
85	March	26	12	0.00	227.00	-2.9	0.85	1.39	0.65
85	March	26	13	0.00	294.00	-2.4	0.83	1.39	0.57
85	March	26	14	0.00	269.00	-2.1	0.86	1.39	0.60
85	March	26	15	0.00	250.00	-1.7	0.86	1.11	0.61
85	March	26	16	0.00	254.00	-1.4	0.85	1.67	0.56
85	March	26	17	0.00	191.00	-1.5	0.86	2.22	0.59
85	March	26	18	0.00	76.00	-1.7	0.87	3.06	0.61
85	March	26	19	0.00	39.00	-1.7	0.87	2.78	0.63
85	March	26	20	0.00	6.00	-1.7	0.87	2.78	0.64
85	March	26	21	0.00	0.00	-1.5	0.86	3.06	0.66
85	March	26	22	0.00	0.00	-1.7	0.86	3.33	0.68
85	March	26	23	0.00	0.00	-1.9	0.86	4.44	0.70
85	March	26	24	0.00	0.00	-2.1	0.86	4.17	0.72
86	March	27	1	0.00	0.00	-2.2	0.85	4.72	0.73
86	March	27	2	0.00	0.00	-2.3	0.84	4.72	0.75
86	March	27	3	0.00	0.00	-2.4	0.86	5.00	0.77
86	March	27	4	0.00	0.00	-2.4	0.90	5.00	0.79
86	March	27	5	0.00	0.00	-2.3	0.91	5.00	0.81
86	March	27	6	0.00	0.00	-2.1	0.92	5.00	0.83
86	March	27	7	0.00	0.00	-2.1	0.93	5.28	0.84
86	March	27	8	0.00	7.00	-2.2	0.92	5.56	0.86
86	March	27	9	0.00	34.00	-2.2	0.92	5.28	0.88
86	March	27	10	0.00	67.00	-2.1	0.93	5.56	0.85
86	March	27	11	0.00	147.00	-2.1	0.94	6.11	0.74
86	March	27	12	0.00	156.00	-1.5	0.95	5.56	0.76
86	March	27	13	0.00	144.00	-0.5	0.94	6.39	0.79
86	March	27	14	0.00	114.00	-0.3	0.95	6.39	0.83
86	March	27	15	0.00	117.00	-0.2	0.95	6.94	0.82
86	March	27	16	0.00	110.00	-0.2	0.95	6.67	0.81
86	March	27	17	0.00	85.00	-0.5	0.96	5.28	0.82
86	March	27	18	0.00	60.00	-0.8	0.96	4.72	0.82
86	March	27	19	0.00	40.00	-1.1	0.96	4.72	0.82
86	March	27	20	0.00	18.00	-1.3	0.96	3.89	0.82
86	March	27	21	0.00	11.00	-1.5	0.95	3.61	0.82
86	March	27	22	0.00	0.00	-1.6	0.95	3.61	0.82
86	March	27	23	0.00	0.00	-2.0	0.95	3.61	0.82
86	March	27	24	0.00	0.00	-2.2	0.95	3.06	0.82
87	March	28	1	0.00	0.00	-2.8	0.95	3.61	0.81
87	March	28	2	0.00	0.00	-3.2	0.94	3.33	0.81
87	March	28	3	0.00	0.00	-3.3	0.94	3.06	0.81
87	March	28	4	0.00	0.00	-3.7	0.94	2.78	0.81
87	March	28	5	0.00	0.00	-3.9	0.94	1.67	0.81
87	March	28	6	0.00	0.00	-4.0	0.94	1.39	0.81

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
87	March	28	7	0.00	0.00	-4.1	0.93	1.67	0.81
87	March	28	8	0.00	13.00	-4.3	0.93	1.94	0.81
87	March	28	9	0.00	52.00	-4.3	0.93	1.67	0.81
87	March	28	10	0.00	129.00	-4.2	0.93	2.22	0.70
87	March	28	11	0.00	249.00	-3.8	0.93	2.22	0.57
87	March	28	12	0.00	311.00	-3.4	0.92	1.94	0.52
87	March	28	13	0.00	272.00	-3.2	0.91	1.39	0.60
87	March	28	14	0.00	277.00	-3.0	0.90	1.39	0.59
87	March	28	15	0.00	318.00	-2.9	0.89	1.67	0.51
87	March	28	16	0.00	358.00	-2.7	0.89	1.67	0.38
87	March	28	17	0.00	273.00	-2.6	0.89	1.94	0.42
87	March	28	18	0.00	142.00	-2.8	0.90	1.94	0.44
87	March	28	19	0.00	91.00	-3.0	0.90	1.67	0.45
87	March	28	20	0.00	20.00	-3.3	0.90	1.94	0.47
87	March	28	21	0.00	0.00	-3.3	0.90	1.67	0.48
87	March	28	22	0.00	0.00	-3.4	0.90	1.67	0.50
87	March	28	23	0.00	0.00	-3.6	0.91	1.67	0.52
87	March	28	24	0.00	0.00	-3.9	0.91	1.94	0.53
88	March	29	1	0.00	0.00	-4.0	0.91	1.67	0.55
88	March	29	2	0.00	0.00	-3.9	0.91	1.94	0.57
88	March	29	3	0.00	0.00	-3.9	0.91	1.11	0.58
88	March	29	4	0.00	0.00	-3.6	0.92	1.11	0.60
88	March	29	5	0.00	0.00	-3.4	0.92	1.11	0.61
88	March	29	6	0.00	0.00	-3.2	0.93	1.39	0.63
88	March	29	7	0.00	0.00	-3.3	0.93	0.83	0.65
88	March	29	8	0.00	18.00	-2.9	0.92	0.00	0.66
88	March	29	9	0.00	88.00	-2.4	0.91	0.83	0.68
88	March	29	10	0.00	177.00	-2.1	0.90	1.67	0.59
88	March	29	11	0.00	296.00	-1.6	0.90	2.50	0.49
88	March	29	12	0.00	361.00	-1.2	0.90	3.33	0.44
88	March	29	13	0.00	516.00	-0.7	0.89	3.33	0.24
88	March	29	14	0.00	656.00	0.0	0.87	3.06	0.04
88	March	29	15	0.00	659.00	1.3	0.79	2.78	0.00
88	March	29	16	0.00	575.00	3.5	0.68	3.06	0.00
88	March	29	17	0.00	465.00	4.5	0.60	2.78	0.01
88	March	29	18	0.00	320.00	4.5	0.59	3.06	0.03
88	March	29	19	0.00	172.00	4.3	0.59	2.22	0.04
88	March	29	20	0.00	36.00	2.6	0.65	0.83	0.06
88	March	29	21	0.00	0.00	0.4	0.70	0.56	0.08
88	March	29	22	0.00	0.00	-0.9	0.79	0.56	0.10
88	March	29	23	0.00	0.00	-1.4	0.83	0.00	0.11
88	March	29	24	0.00	0.00	-2.7	0.87	1.39	0.13
89	March	30	1	0.00	0.00	-2.2	0.84	1.67	0.15
89	March	30	2	0.00	0.00	-2.6	0.81	1.67	0.17
89	March	30	3	0.00	0.00	-2.7	0.80	1.94	0.18

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
89	March	30	4	0.00	0.00	-2.6	0.78	1.67	0.20
89	March	30	5	0.00	0.00	-3.2	0.80	0.83	0.22
89	March	30	6	0.00	0.00	-4.2	0.83	0.56	0.24
89	March	30	7	0.00	0.00	-4.6	0.85	1.67	0.25
89	March	30	8	0.00	49.00	-4.5	0.84	1.94	0.27
89	March	30	9	0.00	198.00	-3.4	0.79	1.94	0.29
89	March	30	10	0.00	350.00	-1.0	0.70	1.94	0.20
89	March	30	11	0.00	490.00	1.2	0.60	2.22	0.15
89	March	30	12	0.00	601.00	2.8	0.56	2.50	0.07
89	March	30	13	0.00	667.00	3.8	0.55	3.06	0.02
89	March	30	14	0.00	689.00	4.9	0.54	2.78	0.00
89	March	30	15	0.00	662.00	5.9	0.53	2.78	0.00
89	March	30	16	0.00	590.00	7.3	0.50	3.06	0.00
89	March	30	17	0.00	477.00	7.9	0.53	3.33	0.00
89	March	30	18	0.00	335.00	7.4	0.54	3.06	0.04
89	March	30	19	0.00	169.00	6.5	0.53	3.06	0.07
89	March	30	20	0.00	27.00	3.8	0.57	2.50	0.11
89	March	30	21	0.00	0.00	0.7	0.73	2.22	0.14
89	March	30	22	0.00	0.00	0.1	0.81	2.50	0.18
89	March	30	23	0.00	0.00	0.0	0.84	3.06	0.22
89	March	30	24	0.00	0.00	0.0	0.76	3.33	0.25
90	March	31	1	0.00	0.00	0.1	0.72	3.61	0.29
90	March	31	2	0.00	0.00	-0.4	0.74	3.61	0.33
90	March	31	3	0.00	0.00	-1.1	0.79	2.50	0.36
90	March	31	4	0.00	0.00	-1.6	0.82	1.94	0.40
90	March	31	5	0.00	0.00	-1.9	0.83	2.50	0.43
90	March	31	6	0.00	0.00	-2.0	0.85	2.22	0.47
90	March	31	7	0.00	0.00	-2.5	0.84	1.94	0.51
90	March	31	8	0.00	25.00	-2.9	0.85	2.22	0.54
90	March	31	9	0.00	117.00	-1.0	0.74	2.78	0.58
90	March	31	10	0.00	303.00	1.6	0.65	3.33	0.30
90	March	31	11	0.00	370.00	3.0	0.61	3.06	0.36
90	March	31	12	0.00	594.00	4.2	0.58	4.17	0.08
90	March	31	13	0.00	661.00	5.3	0.55	5.56	0.03
90	March	31	14	0.00	682.00	6.1	0.55	4.44	0.00
90	March	31	15	0.00	654.00	7.3	0.53	4.44	0.00
90	March	31	16	0.00	490.00	7.1	0.52	3.61	0.15
90	March	31	17	0.00	290.00	6.7	0.53	3.61	0.38
90	March	31	18	0.00	286.00	6.5	0.55	3.89	0.37
90	March	31	19	0.00	179.00	5.7	0.55	4.44	0.36
90	March	31	20	0.00	30.00	3.2	0.66	2.50	0.36
90	March	31	21	0.00	0.00	1.1	0.75	1.67	0.35
90	March	31	22	0.00	0.00	0.4	0.79	1.94	0.34
90	March	31	23	0.00	0.00	0.0	0.79	2.50	0.34
90	March	31	24	0.00	0.00	-0.2	0.77	2.78	0.33

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
91	April	1	1	0.00	0.00	0.0	0.75	2.78	0.32
91	April	1	2	0.00	0.00	-0.8	0.78	2.22	0.31
91	April	1	3	0.00	0.00	-1.6	0.83	1.94	0.30
91	April	1	4	0.00	0.00	-1.4	0.81	2.50	0.30
91	April	1	5	0.00	0.00	-0.6	0.79	3.06	0.29
91	April	1	6	0.00	0.00	-0.9	0.76	3.33	0.28
91	April	1	7	0.00	0.00	-1.4	0.75	3.33	0.28
91	April	1	8	0.00	52.00	-1.5	0.74	2.50	0.27
91	April	1	9	0.00	206.00	0.0	0.72	3.33	0.26
91	April	1	10	0.00	360.00	1.8	0.66	3.61	0.17
91	April	1	11	0.00	499.00	3.3	0.60	3.06	0.16
91	April	1	12	0.00	605.00	4.4	0.55	3.33	0.09
91	April	1	13	0.00	671.00	5.3	0.51	2.78	0.08
91	April	1	14	0.00	693.00	6.1	0.47	2.78	0.08
91	April	1	15	0.00	666.00	6.6	0.45	3.06	0.07
91	April	1	16	0.00	594.00	7.2	0.41	2.50	0.10
91	April	1	17	0.00	481.00	7.6	0.38	1.67	0.14
91	April	1	18	0.00	341.00	7.8	0.35	1.39	0.17
91	April	1	19	0.00	183.00	7.7	0.33	0.83	0.20
91	April	1	20	0.00	46.00	4.9	0.46	0.83	0.22
91	April	1	21	0.00	0.00	0.8	0.65	1.94	0.25
91	April	1	22	0.00	0.00	-0.3	0.71	1.94	0.28
91	April	1	23	0.00	0.00	-0.1	0.65	2.22	0.31
91	April	1	24	0.00	0.00	-0.6	0.68	2.22	0.34
92	April	2	1	0.00	0.00	-1.2	0.75	2.22	0.36
92	April	2	2	0.00	0.00	-1.2	0.73	2.50	0.39
92	April	2	3	0.00	0.00	-1.3	0.74	3.06	0.42
92	April	2	4	0.00	0.00	-1.0	0.71	3.33	0.45
92	April	2	5	0.00	0.00	-2.0	0.78	2.50	0.48
92	April	2	6	0.00	0.00	-2.3	0.82	2.78	0.51
92	April	2	7	0.00	0.00	-2.3	0.84	3.06	0.53
92	April	2	8	0.00	40.00	-1.7	0.82	3.61	0.56
92	April	2	9	0.00	114.00	-0.4	0.78	3.06	0.59
92	April	2	10	0.00	301.00	1.3	0.73	2.50	0.34
92	April	2	11	0.00	364.00	2.5	0.70	1.94	0.39
92	April	2	12	0.00	509.00	3.8	0.67	1.94	0.23
92	April	2	13	0.00	581.00	5.2	0.60	2.22	0.21
92	April	2	14	0.00	615.00	6.7	0.54	2.22	0.18
92	April	2	15	0.00	514.00	7.4	0.50	2.22	0.28
92	April	2	16	0.00	537.00	8.2	0.44	0.83	0.19
92	April	2	17	0.00	394.00	8.5	0.41	0.28	0.29
92	April	2	18	0.00	318.00	7.2	0.51	3.06	0.31
92	April	2	19	0.00	163.00	5.6	0.60	3.61	0.34
92	April	2	20	0.00	44.00	3.8	0.69	3.06	0.36
92	April	2	21	0.00	0.00	2.0	0.79	1.39	0.38

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
92	April	2	22	0.00	0.00	1.2	0.86	0.83	0.41
92	April	2	23	0.00	0.00	0.8	0.90	1.39	0.43
92	April	2	24	0.00	0.00	0.1	0.90	0.83	0.45
93	April	3	1	0.00	0.00	-0.3	0.91	0.56	0.47
93	April	3	2	0.00	0.00	0.7	0.89	0.83	0.50
93	April	3	3	0.00	0.00	-0.1	0.91	1.39	0.52
93	April	3	4	0.00	0.00	-0.3	0.93	2.22	0.54
93	April	3	5	0.00	0.00	-0.6	0.92	0.83	0.57
93	April	3	6	0.00	0.00	-1.3	0.93	1.11	0.59
93	April	3	7	0.00	0.00	-1.7	0.94	1.39	0.61
93	April	3	8	0.00	59.00	-1.3	0.94	1.11	0.64
93	April	3	9	0.00	94.00	-0.2	0.94	1.67	0.66
93	April	3	10	0.00	115.00	0.5	0.93	1.94	0.75
93	April	3	11	0.00	162.00	1.4	0.92	1.94	0.73
93	April	3	12	0.00	226.00	2.2	0.85	2.22	0.66
93	April	3	13	0.00	342.00	2.8	0.81	1.11	0.53
93	April	3	14	0.00	721.00	4.8	0.71	1.94	0.04
93	April	3	15	0.00	193.00	4.3	0.71	2.22	0.73
93	April	3	16	0.00	180.00	4.3	0.69	2.78	0.73
93	April	3	17	0.00	226.00	4.2	0.72	5.00	0.59
93	April	3	18	0.00	330.00	4.3	0.72	3.33	0.56
93	April	3	19	0.00	171.00	4.7	0.67	2.50	0.53
93	April	3	20	0.00	24.00	2.8	0.74	1.67	0.51
93	April	3	21	0.00	0.00	1.5	0.80	1.39	0.48
93	April	3	22	0.00	0.00	0.1	0.86	0.83	0.45
93	April	3	23	0.00	0.00	0.0	0.88	1.39	0.42
93	April	3	24	0.00	0.00	-0.7	0.86	0.83	0.40
94	April	4	1	0.00	0.00	-1.1	0.86	1.11	0.37
94	April	4	2	0.00	0.00	-1.5	0.88	1.39	0.34
94	April	4	3	0.00	0.00	-1.7	0.89	1.67	0.32
94	April	4	4	0.00	0.00	-1.8	0.90	1.67	0.29
94	April	4	5	0.00	0.00	-2.2	0.89	1.39	0.26
94	April	4	6	0.00	0.00	-2.3	0.86	1.94	0.23
94	April	4	7	0.00	0.00	-2.5	0.82	1.39	0.21
94	April	4	8	0.00	84.00	-1.7	0.78	1.94	0.18
94	April	4	9	0.00	238.00	0.5	0.73	3.06	0.15
94	April	4	10	0.00	374.00	2.4	0.66	3.89	0.18
94	April	4	11	0.00	511.00	4.1	0.58	4.72	0.14
94	April	4	12	0.00	615.00	5.6	0.54	4.44	0.07
94	April	4	13	0.00	677.00	6.6	0.50	4.44	0.08
94	April	4	14	0.00	693.00	7.1	0.45	4.17	0.08
94	April	4	15	0.00	663.00	8.1	0.43	4.44	0.07
94	April	4	16	0.00	522.00	8.2	0.41	4.17	0.21
94	April	4	17	0.00	332.00	7.8	0.41	3.89	0.41
94	April	4	18	0.00	287.00	8.1	0.40	3.06	0.42

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
94	April	4	19	0.00	178.00	7.8	0.38	2.78	0.44
94	April	4	20	0.00	55.00	6.4	0.47	0.83	0.45
94	April	4	21	0.00	0.00	4.0	0.50	0.83	0.47
94	April	4	22	0.00	0.00	1.5	0.64	2.50	0.48
94	April	4	23	0.00	0.00	-0.7	0.82	1.67	0.50
94	April	4	24	0.00	0.00	-1.1	0.78	1.39	0.52
95	April	5	1	0.00	0.00	-1.5	0.84	1.11	0.53
95	April	5	2	0.00	0.00	-1.8	0.84	1.39	0.55
95	April	5	3	0.00	0.00	-1.3	0.80	2.22	0.56
95	April	5	4	0.00	0.00	-1.6	0.83	1.94	0.57
95	April	5	5	0.00	0.00	-2.1	0.84	1.94	0.59
95	April	5	6	0.00	0.00	-2.1	0.85	1.67	0.60
95	April	5	7	0.00	0.00	-1.7	0.82	2.22	0.62
95	April	5	8	0.00	52.00	-1.0	0.81	2.22	0.64
95	April	5	9	0.00	98.00	1.8	0.77	1.67	0.65
95	April	5	10	0.00	186.00	3.6	0.72	1.39	0.59
95	April	5	11	0.00	209.25	8.0	0.70	3.06	0.65
95	April	5	12	0.00	418.50	8.0	0.68	3.06	0.37
95	April	5	13	0.00	383.63	7.8	0.64	3.33	0.48
95	April	5	14	0.00	313.88	7.2	0.54	3.33	0.58
95	April	5	15	0.00	226.69	7.0	0.47	3.06	0.68
95	April	5	16	0.00	174.38	6.0	0.53	1.94	0.74
95	April	5	17	0.00	174.38	5.0	0.68	2.22	0.69
95	April	5	18	0.00	156.94	4.0	0.85	2.50	0.67
95	April	5	19	0.00	104.63	2.5	0.95	2.50	0.66
95	April	5	20	0.00	41.85	1.8	0.99	3.06	0.64
95	April	5	21	0.00	6.98	1.2	0.99	2.22	0.63
95	April	5	22	0.00	0.00	0.8	0.99	1.94	0.61
95	April	5	23	0.00	0.00	0.2	0.99	1.39	0.60
95	April	5	24	0.00	0.00	-0.5	0.99	1.39	0.58
96	April	6	1	0.00	0.00	-1.0	0.99	1.39	0.56
96	April	6	2	0.00	0.00	-1.5	0.99	1.11	0.55
96	April	6	3	0.00	0.00	-2.2	0.98	1.11	0.53
96	April	6	4	0.00	0.00	-2.5	0.97	1.39	0.52
96	April	6	5	0.00	0.00	-2.5	0.96	1.11	0.50
96	April	6	6	0.00	0.00	-2.8	0.95	1.11	0.49
96	April	6	7	0.00	17.44	-3.2	0.94	1.11	0.47
96	April	6	8	0.00	52.31	-2.8	0.94	1.11	0.46
96	April	6	9	0.00	156.94	-1.0	0.95	0.83	0.44
96	April	6	10	0.00	296.44	1.2	0.86	2.22	0.35
96	April	6	11	0.00	348.75	3.2	0.70	1.94	0.41
96	April	6	12	0.00	383.63	5.2	0.56	2.22	0.42
96	April	6	13	0.00	418.50	6.8	0.43	2.50	0.43
96	April	6	14	0.00	418.50	7.2	0.34	2.78	0.44
96	April	6	15	0.00	453.37	7.8	0.30	2.22	0.37

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
96	April	6	16	0.00	418.50	7.5	0.25	3.06	0.37
96	April	6	17	0.00	313.88	6.5	0.26	1.67	0.44
96	April	6	18	0.00	244.12	5.5	0.26	1.11	0.45
96	April	6	19	0.00	156.94	4.8	0.25	1.39	0.46
96	April	6	20	0.00	87.19	4.0	0.32	1.11	0.47
96	April	6	21	0.00	41.85	3.2	0.39	2.22	0.48
96	April	6	22	0.00	6.98	2.2	0.52	1.39	0.50
96	April	6	23	0.00	0.00	1.2	0.70	0.00	0.51
96	April	6	24	0.00	0.00	0.8	0.82	0.28	0.52
97	April	7	1	0.00	0.00	0.2	0.86	1.11	0.53
97	April	7	2	0.00	0.00	0.0	0.88	1.11	0.54
97	April	7	3	0.00	0.00	-0.1	0.89	0.83	0.55
97	April	7	4	0.00	0.00	-0.3	0.85	1.39	0.56
97	April	7	5	0.00	0.00	-0.8	0.83	1.39	0.57
97	April	7	6	0.00	0.00	-0.8	0.86	1.94	0.59
97	April	7	7	0.00	6.98	-0.2	0.89	2.22	0.60
97	April	7	8	0.00	41.85	-0.5	0.84	2.78	0.61
97	April	7	9	0.00	104.63	-0.5	0.85	2.22	0.62
97	April	7	10	0.00	139.50	0.2	0.88	1.39	0.69
97	April	7	11	0.00	139.50	0.8	0.82	1.11	0.76
97	April	7	12	0.10	174.38	0.8	0.82	1.11	0.74
97	April	7	13	0.30	209.25	0.8	0.86	2.78	0.71
97	April	7	14	0.10	139.50	0.5	0.89	2.22	0.81
97	April	7	15	0.00	69.75	-0.5	0.90	5.56	0.90
97	April	7	16	1.00	104.63	-0.5	0.90	3.06	0.84
97	April	7	17	2.20	174.38	0.5	0.89	1.94	0.69
97	April	7	18	0.10	174.38	0.5	0.84	3.06	0.65
97	April	7	19	0.10	139.50	-0.5	0.82	2.78	0.60
97	April	7	20	0.10	76.72	-1.0	0.87	3.89	0.56
97	April	7	21	0.00	6.98	-1.5	0.90	4.44	0.52
97	April	7	22	0.00	0.00	-2.0	0.89	5.83	0.47
97	April	7	23	0.00	0.00	-2.5	0.86	5.28	0.43
97	April	7	24	0.00	0.00	-4.0	0.83	3.61	0.39
98	April	8	1	0.00	0.00	-5.5	0.80	1.39	0.34
98	April	8	2	0.00	0.00	-7.0	0.80	0.28	0.30
98	April	8	3	0.00	0.00	-8.5	0.85	0.28	0.26
98	April	8	4	0.00	0.00	-9.0	0.89	0.28	0.22
98	April	8	5	0.00	0.00	-9.5	0.89	0.00	0.17
98	April	8	6	0.00	0.00	-9.8	0.89	0.00	0.13
98	April	8	7	0.00	69.75	-8.2	0.89	0.00	0.09
98	April	8	8	0.00	209.25	-6.0	0.88	0.00	0.04
98	April	8	9	0.00	348.75	-4.2	0.88	0.28	0.00
98	April	8	10	0.00	453.37	-3.0	0.81	0.83	0.00
98	April	8	11	0.00	610.31	-2.2	0.71	2.50	0.00
98	April	8	12	0.00	645.19	-1.5	0.59	3.61	0.03

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
98	April	8	13	0.00	645.19	-0.5	0.48	3.89	0.12
98	April	8	14	0.00	610.31	0.2	0.46	4.44	0.19
98	April	8	15	0.00	488.25	0.8	0.45	5.56	0.32
98	April	8	16	0.00	348.75	1.0	0.41	4.44	0.47
98	April	8	17	0.00	313.87	1.2	0.39	3.89	0.44
98	April	8	18	0.00	296.44	1.2	0.39	3.89	0.42
98	April	8	19	0.00	122.06	0.0	0.41	4.17	0.40
98	April	8	20	0.00	34.88	-1.0	0.56	2.22	0.39
98	April	8	21	0.00	0.00	-1.5	0.70	0.83	0.37
98	April	8	22	0.00	0.00	-2.5	0.75	0.83	0.35
98	April	8	23	0.00	0.00	-3.5	0.84	1.94	0.33
98	April	8	24	0.00	0.00	-4.0	0.89	1.67	0.31
99	April	9	1	0.00	0.00	-4.0	0.89	1.94	0.29
99	April	9	2	0.00	0.00	-4.5	0.89	1.94	0.28
99	April	9	3	0.00	0.00	-5.0	0.89	1.39	0.26
99	April	9	4	0.00	0.00	-5.0	0.89	2.22	0.24
99	April	9	5	0.00	0.00	-5.0	0.88	1.39	0.22
99	April	9	6	0.00	0.00	-5.5	0.88	1.94	0.20
99	April	9	7	0.00	6.98	-5.8	0.89	2.78	0.19
99	April	9	8	0.00	69.75	-5.2	0.89	2.50	0.17
99	April	9	9	0.00	237.15	-3.5	0.88	2.78	0.15
99	April	9	10	0.00	418.50	-1.5	0.84	3.06	0.08
99	April	9	11	0.00	523.12	0.0	0.77	3.89	0.12
99	April	9	12	0.00	627.75	1.8	0.68	3.89	0.05
99	April	9	13	0.00	697.50	3.2	0.59	3.06	0.05
99	April	9	14	0.00	662.62	4.5	0.52	2.78	0.12
99	April	9	15	0.00	627.75	5.5	0.45	3.06	0.12
99	April	9	16	0.00	488.25	5.5	0.40	2.50	0.26
99	April	9	17	0.00	279.00	5.5	0.36	1.94	0.50
99	April	9	18	0.00	244.12	5.5	0.34	2.22	0.47
99	April	9	19	0.00	209.25	4.5	0.34	2.50	0.44
99	April	9	20	0.00	76.72	3.0	0.39	1.11	0.41
99	April	9	21	0.00	6.98	0.5	0.44	0.28	0.38
99	April	9	22	0.00	0.00	-1.5	0.54	1.67	0.34
99	April	9	23	0.00	0.00	-2.2	0.68	1.11	0.31
99	April	9	24	0.00	0.00	-3.2	0.77	0.00	0.28
100	April	10	1	0.00	0.00	-4.2	0.79	0.00	0.25
100	April	10	2	0.00	0.00	-4.8	0.84	0.00	0.22
100	April	10	3	0.00	0.00	-5.0	0.88	0.00	0.19
100	April	10	4	0.00	0.00	-5.2	0.88	0.00	0.16
100	April	10	5	0.00	0.00	-5.8	0.88	0.28	0.12
100	April	10	6	0.00	0.00	-6.2	0.88	0.00	0.09
100	April	10	7	0.00	69.75	-5.8	0.89	1.11	0.06
100	April	10	8	0.00	226.69	-3.8	0.91	0.83	0.03
100	April	10	9	0.00	401.06	-0.8	0.91	2.22	0.00

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
100	April	10	10	0.00	523.12	2.5	0.78	2.50	0.00
100	April	10	11	0.00	585.90	5.0	0.53	1.67	0.01
100	April	10	12	0.00	613.80	6.8	0.36	1.39	0.07
100	April	10	13	0.00	610.31	8.0	0.28	1.39	0.17
100	April	10	14	0.00	599.85	9.2	0.23	1.94	0.20
100	April	10	15	0.00	575.44	9.8	0.22	1.39	0.20
100	April	10	16	0.00	540.56	10.0	0.21	1.39	0.18
100	April	10	17	0.00	366.19	10.2	0.20	1.67	0.34
100	April	10	18	0.00	244.12	10.0	0.21	1.11	0.32
100	April	10	19	0.00	209.25	10.0	0.23	0.83	0.30
100	April	10	20	0.00	69.75	7.5	0.24	0.28	0.28
100	April	10	21	0.00	0.00	4.0	0.33	1.67	0.26
100	April	10	22	0.00	0.00	2.5	0.50	1.94	0.23
100	April	10	23	0.00	0.00	1.5	0.62	2.22	0.21
100	April	10	24	0.00	0.00	-0.5	0.69	1.94	0.19
101	April	11	1	0.00	0.00	-1.2	0.76	1.94	0.17
101	April	11	2	0.00	0.00	-0.8	0.77	2.22	0.15
101	April	11	3	0.00	0.00	-0.8	0.75	1.94	0.13
101	April	11	4	0.00	0.00	-1.8	0.72	1.94	0.11
101	April	11	5	0.00	0.00	-2.0	0.75	1.94	0.09
101	April	11	6	0.00	0.00	-2.0	0.79	1.94	0.06
101	April	11	7	0.00	62.77	-3.2	0.77	2.22	0.04
101	April	11	8	0.00	167.40	-1.2	0.78	2.50	0.02
101	April	11	9	0.00	279.00	2.2	0.84	2.50	0.00
101	April	11	10	0.00	418.50	5.2	0.73	3.33	0.08
101	April	11	11	0.00	558.00	7.8	0.56	2.78	0.06
101	April	11	12	0.00	634.73	10.2	0.47	2.22	0.04
101	April	11	13	0.00	652.16	12.5	0.40	2.50	0.11
101	April	11	14	0.00	652.16	13.5	0.35	3.06	0.13
101	April	11	15	0.00	634.73	14.5	0.32	3.06	0.11
101	April	11	16	0.00	592.88	15.0	0.28	2.22	0.11
101	April	11	17	0.00	523.12	15.0	0.23	2.78	0.06
101	April	11	18	0.00	418.50	14.8	0.20	2.22	0.06
101	April	11	19	0.00	279.00	14.2	0.20	2.22	0.05
101	April	11	20	0.00	139.50	12.5	0.23	1.39	0.05
101	April	11	21	0.00	34.88	8.5	0.28	0.28	0.04
101	April	11	22	0.00	0.00	4.5	0.40	0.28	0.04
101	April	11	23	0.00	0.00	2.8	0.65	1.67	0.04
101	April	11	24	0.00	0.00	2.5	0.79	1.94	0.03
102	April	12	1	0.00	0.00	2.8	0.78	2.50	0.03
102	April	12	2	0.00	0.00	3.2	0.76	2.78	0.03
102	April	12	3	0.00	0.00	3.8	0.76	1.94	0.02
102	April	12	4	0.00	0.00	4.5	0.77	1.11	0.02
102	April	12	5	0.00	0.00	5.5	0.76	1.94	0.01
102	April	12	6	0.00	0.00	6.5	0.76	1.39	0.01

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
102	April	12	7	0.00	34.88	8.0	0.76	2.22	0.01
102	April	12	8	0.00	174.38	9.5	0.68	3.61	0.00
102	April	12	9	0.00	348.75	11.0	0.55	3.89	0.00
102	April	12	10	0.00	523.12	12.0	0.45	4.72	0.00
102	April	12	11	0.00	523.12	12.5	0.34	5.83	0.12
102	April	12	12	0.00	540.56	13.5	0.26	6.67	0.18
102	April	12	13	0.00	575.44	13.8	0.28	7.50	0.21
102	April	12	14	0.00	453.37	13.8	0.31	10.56	0.40
102	April	12	15	0.00	383.63	14.0	0.32	9.72	0.46
102	April	12	16	0.00	313.88	14.0	0.29	9.72	0.53
102	April	12	17	0.00	244.12	13.5	0.23	8.61	0.56
102	April	12	18	0.00	191.81	12.8	0.24	8.61	0.53
102	April	12	19	0.00	156.94	11.8	0.31	6.39	0.49
102	April	12	20	0.00	87.19	10.0	0.40	3.89	0.46
102	April	12	21	0.00	17.44	8.0	0.53	2.78	0.42
102	April	12	22	0.00	0.00	5.8	0.65	2.50	0.39
102	April	12	23	0.00	0.00	3.5	0.75	1.67	0.35
102	April	12	24	0.00	0.00	2.2	0.82	0.83	0.32
103	April	13	1	0.00	0.00	0.8	0.86	0.83	0.28
103	April	13	2	0.00	0.00	-1.2	0.90	0.28	0.24
103	April	13	3	0.00	0.00	-2.5	0.93	0.56	0.21
103	April	13	4	0.00	0.00	-3.2	0.94	0.83	0.18
103	April	13	5	0.00	0.00	-3.2	0.94	0.28	0.14
103	April	13	6	0.00	0.00	-2.8	0.93	0.56	0.10
103	April	13	7	0.00	34.88	-1.8	0.92	0.28	0.07
103	April	13	8	0.00	174.38	0.5	0.91	0.56	0.04
103	April	13	9	0.00	348.75	3.5	0.85	1.39	0.00
103	April	13	10	0.00	523.12	6.0	0.75	3.06	0.00
103	April	13	11	0.00	592.88	8.5	0.62	4.17	0.00
103	April	13	12	0.00	627.75	10.5	0.48	5.28	0.05
103	April	13	13	0.00	714.94	11.8	0.38	6.11	0.02
103	April	13	14	0.00	680.06	12.0	0.33	5.83	0.09
103	April	13	15	0.00	558.00	11.2	0.32	6.67	0.22
103	April	13	16	0.00	383.63	10.5	0.30	7.50	0.42
103	April	13	17	0.00	383.63	9.8	0.32	6.39	0.31
103	April	13	18	0.00	383.63	9.2	0.40	5.83	0.30
103	April	13	19	0.00	244.12	9.0	0.42	5.83	0.30
103	April	13	20	0.00	139.50	8.0	0.36	4.44	0.29
103	April	13	21	0.00	34.88	6.5	0.38	1.94	0.28
103	April	13	22	0.00	0.00	3.5	0.48	1.67	0.28
103	April	13	23	0.00	0.00	-0.5	0.64	2.22	0.27
103	April	13	24	0.00	0.00	-2.5	0.82	2.22	0.27
104	April	14	1	0.00	0.00	-3.0	0.90	0.56	0.26
104	April	14	2	0.00	0.00	-3.5	0.89	0.28	0.25
104	April	14	3	0.00	0.00	-4.2	0.90	0.00	0.25

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
104	April	14	4	0.00	0.00	-5.2	0.91	0.28	0.24
104	April	14	5	0.00	0.00	-5.5	0.92	1.11	0.23
104	April	14	6	0.00	0.00	-5.5	0.92	1.39	0.23
104	April	14	7	0.00	17.44	-4.8	0.90	1.67	0.22
104	April	14	8	0.00	80.21	-2.2	0.88	2.22	0.22
104	April	14	9	0.00	219.71	0.8	0.84	3.06	0.21
104	April	14	10	0.00	366.19	4.2	0.76	4.17	0.19
104	April	14	11	0.00	523.12	7.5	0.61	5.56	0.12
104	April	14	12	0.00	662.62	10.0	0.46	5.83	0.00
104	April	14	13	0.00	725.40	11.5	0.36	5.56	0.01
104	April	14	14	0.00	760.28	12.5	0.29	5.28	0.00
104	April	14	15	0.00	749.81	13.5	0.29	6.11	0.00
104	April	14	16	0.00	714.94	14.5	0.28	6.94	0.00
104	April	14	17	0.00	592.88	15.8	0.27	5.28	0.00
104	April	14	18	0.00	418.50	16.2	0.27	4.72	0.00
104	April	14	19	0.00	244.12	15.2	0.26	3.89	0.00
104	April	14	20	0.00	87.19	13.8	0.28	1.94	0.00
104	April	14	21	0.00	17.44	11.5	0.33	1.67	0.00
104	April	14	22	0.00	0.00	9.8	0.42	1.67	0.00
104	April	14	23	0.00	0.00	9.2	0.51	1.67	0.00
104	April	14	24	0.00	0.00	8.0	0.57	1.11	0.00
105	April	15	1	0.00	0.00	8.0	0.59	1.67	0.00
105	April	15	2	0.00	0.00	8.5	0.65	1.67	0.00
105	April	15	3	0.00	0.00	7.2	0.65	3.61	0.00
105	April	15	4	0.00	0.00	7.0	0.67	4.44	0.00
105	April	15	5	0.00	0.00	5.8	0.73	8.61	0.00
105	April	15	6	0.00	0.00	3.9	0.81	3.33	0.00
105	April	15	7	0.00	24.41	3.9	0.90	4.44	0.00
105	April	15	8	0.00	94.16	4.5	0.89	7.22	0.00
105	April	15	9	0.00	313.87	6.0	0.77	8.89	0.00
105	April	15	10	0.00	558.00	7.2	0.58	9.72	0.00
105	April	15	11	0.00	662.62	8.0	0.46	10.83	0.00
105	April	15	12	0.00	732.38	9.0	0.39	10.56	0.00
105	April	15	13	0.00	784.69	9.5	0.36	10.28	0.00
105	April	15	14	0.00	784.69	9.2	0.34	9.17	0.00
105	April	15	15	0.00	732.38	8.8	0.34	8.89	0.00
105	April	15	16	0.00	662.62	8.2	0.34	8.89	0.00
105	April	15	17	0.00	558.00	8.0	0.38	8.06	0.00
105	April	15	18	0.00	383.63	7.8	0.39	8.06	0.00
105	April	15	19	0.00	174.38	7.2	0.38	7.22	0.00
105	April	15	20	0.00	34.88	6.0	0.38	5.83	0.00
105	April	15	21	0.00	0.00	3.0	0.42	6.11	0.00
105	April	15	22	0.00	0.00	1.5	0.53	8.06	0.00
105	April	15	23	0.00	0.00	1.0	0.70	7.22	0.00
105	April	15	24	0.00	0.00	-0.5	0.82	9.17	0.00

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
106	April	16	1	0.00	0.00	-1.8	0.84	8.33	0.00
106	April	16	2	0.00	0.00	-3.8	0.81	8.06	0.00
106	April	16	3	0.00	0.00	-6.0	0.82	7.78	0.00
106	April	16	4	0.00	0.00	-7.5	0.89	7.50	0.00
106	April	16	5	0.00	0.00	-9.0	0.86	7.22	0.00
106	April	16	6	0.00	0.00	-10.8	0.74	6.94	0.00
106	April	16	7	0.00	34.88	-11.8	0.67	7.22	0.00
106	April	16	8	0.00	174.38	-12.2	0.66	6.67	0.00
106	April	16	9	0.00	383.63	-12.2	0.62	6.11	0.00
106	April	16	10	0.00	558.00	-11.5	0.57	6.39	0.00
106	April	16	11	0.00	680.06	-10.5	0.56	5.56	0.00
106	April	16	12	0.00	749.81	-9.5	0.59	5.28	0.00
106	April	16	13	0.00	795.15	-8.0	0.56	5.28	0.00
106	April	16	14	0.00	802.12	-6.1	0.49	4.44	0.00
106	April	16	15	0.00	770.74	-4.8	0.43	4.17	0.00
106	April	16	16	0.00	694.01	-4.2	0.36	3.89	0.03
106	April	16	17	0.00	523.12	-3.8	0.32	4.44	0.23
106	April	16	18	0.00	348.75	-3.2	0.30	4.17	0.22
106	April	16	19	0.00	191.81	-3.2	0.29	4.44	0.20
106	April	16	20	0.00	52.31	-3.8	0.29	4.17	0.19
106	April	16	21	0.00	0.00	-5.5	0.32	1.94	0.17
106	April	16	22	0.00	0.00	-6.8	0.40	0.83	0.16
106	April	16	23	0.00	0.00	-6.5	0.57	1.67	0.14
106	April	16	24	0.00	0.00	-6.5	0.70	1.94	0.13
107	April	17	1	0.00	0.00	-6.5	0.74	2.50	0.12
107	April	17	2	0.00	0.00	-6.8	0.79	3.06	0.10
107	April	17	3	0.00	0.00	-7.2	0.80	3.89	0.09
107	April	17	4	0.00	0.00	-7.8	0.83	3.06	0.07
107	April	17	5	0.00	0.00	-8.0	0.86	2.78	0.06
107	April	17	6	0.00	0.00	-8.2	0.88	2.22	0.04
107	April	17	7	0.00	52.31	-8.2	0.90	2.50	0.03
107	April	17	8	0.00	191.81	-7.0	0.90	2.50	0.01
107	April	17	9	0.00	366.19	-4.2	0.85	3.33	0.00
107	April	17	10	0.00	523.12	-0.8	0.75	3.33	0.00
107	April	17	11	0.00	645.19	2.5	0.62	4.72	0.00
107	April	17	12	0.00	732.38	5.0	0.48	6.39	0.00
107	April	17	13	0.00	784.69	6.8	0.34	5.83	0.00
107	April	17	14	0.00	791.66	7.8	0.23	6.39	0.00
107	April	17	15	0.00	774.23	8.2	0.18	7.50	0.00
107	April	17	16	0.00	697.50	8.2	0.18	7.22	0.02
107	April	17	17	0.00	558.00	8.0	0.16	7.22	0.18
107	April	17	18	0.00	383.63	8.0	0.17	6.67	0.17
107	April	17	19	0.00	209.25	7.8	0.20	4.72	0.16
107	April	17	20	0.00	69.75	6.2	0.20	2.50	0.15
107	April	17	21	0.00	0.00	3.0	0.24	0.00	0.14

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
107	April	17	22	0.00	0.00	-1.0	0.39	0.56	0.12
107	April	17	23	0.00	0.00	-2.2	0.59	0.56	0.11
107	April	17	24	0.00	0.00	-1.8	0.69	0.28	0.10
108	April	18	1	0.00	0.00	-2.8	0.62	0.28	0.09
108	April	18	2	0.00	0.00	-3.2	0.69	0.83	0.08
108	April	18	3	0.00	0.00	-4.0	0.81	0.83	0.07
108	April	18	4	0.00	0.00	-5.5	0.84	0.56	0.06
108	April	18	5	0.00	0.00	-5.8	0.88	1.11	0.04
108	April	18	6	0.00	0.00	-5.2	0.92	0.83	0.03
108	April	18	7	0.00	34.88	-5.5	0.90	1.67	0.02
108	April	18	8	0.00	156.94	-3.0	0.91	2.22	0.01
108	April	18	9	0.00	331.31	2.0	0.82	1.94	0.00
108	April	18	10	0.00	488.25	6.5	0.60	3.06	0.00
108	April	18	11	0.00	620.77	10.0	0.40	3.89	0.00
108	April	18	12	0.00	707.96	12.0	0.27	3.89	0.00
108	April	18	13	0.00	725.40	13.5	0.22	2.50	0.00
108	April	18	14	0.00	707.96	14.5	0.17	1.39	0.06
108	April	18	15	0.00	697.50	13.8	0.12	2.50	0.07
108	April	18	16	0.00	662.62	14.2	0.10	4.17	0.07
108	April	18	17	0.00	523.12	15.8	0.11	5.00	0.23
108	April	18	18	0.00	348.75	15.2	0.11	4.72	0.22
108	April	18	19	0.00	209.25	14.8	0.11	2.78	0.20
108	April	18	20	0.00	69.75	13.0	0.12	0.28	0.19
108	April	18	21	0.00	0.00	9.2	0.15	0.83	0.17
108	April	18	22	0.00	0.00	5.0	0.28	1.94	0.16
108	April	18	23	0.00	0.00	4.0	0.51	1.67	0.14
108	April	18	24	0.00	0.00	4.5	0.56	1.67	0.13
109	April	19	1	0.00	0.00	2.5	0.53	1.67	0.12
109	April	19	2	0.00	0.00	-0.8	0.56	1.67	0.10
109	April	19	3	0.00	0.00	-1.2	0.59	1.94	0.09
109	April	19	4	0.00	0.00	-0.5	0.64	1.94	0.07
109	April	19	5	0.00	0.00	-2.0	0.70	1.94	0.06
109	April	19	6	0.00	0.00	-3.2	0.81	1.11	0.04
109	April	19	7	0.00	34.88	-3.8	0.89	1.11	0.03
109	April	19	8	0.00	139.50	-2.0	0.91	1.11	0.01
109	April	19	9	0.00	296.44	2.5	0.85	1.94	0.00
109	April	19	10	0.00	435.94	7.8	0.67	3.06	0.04
109	April	19	11	0.00	575.44	12.8	0.43	3.06	0.00
109	April	19	12	0.00	575.44	15.1	0.28	3.06	0.13
109	April	19	13	0.00	453.37	15.1	0.20	3.61	0.37
109	April	19	14	0.00	418.50	15.1	0.17	3.61	0.44
109	April	19	15	0.00	418.50	15.1	0.18	1.94	0.44
109	April	19	16	0.00	348.75	15.1	0.16	2.22	0.51
109	April	19	17	0.00	244.12	15.2	0.15	3.89	0.64
109	April	19	18	0.00	209.25	15.1	0.17	3.89	0.61

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
109	April	19	19	0.00	139.50	15.1	0.17	3.33	0.58
109	April	19	20	0.00	41.85	14.9	0.21	3.61	0.55
109	April	19	21	0.00	6.98	13.4	0.28	3.06	0.53
109	April	19	22	0.00	0.00	9.2	0.35	2.78	0.50
109	April	19	23	0.00	0.00	4.8	0.50	2.78	0.47
109	April	19	24	0.00	0.00	2.5	0.66	1.67	0.44
110	April	20	1	0.00	0.00	2.0	0.80	0.83	0.41
110	April	20	2	0.00	0.00	1.0	0.87	1.39	0.38
110	April	20	3	0.00	0.00	-0.5	0.89	1.39	0.35
110	April	20	4	0.00	0.00	-0.5	0.93	1.94	0.32
110	April	20	5	0.00	0.00	-0.2	0.91	2.22	0.29
110	April	20	6	0.00	0.00	-0.2	0.86	1.94	0.27
110	April	20	7	0.00	34.88	1.0	0.83	1.67	0.24
110	April	20	8	0.00	104.63	3.0	0.81	1.94	0.21
110	April	20	9	0.00	244.12	4.5	0.79	2.78	0.18
110	April	20	10	0.00	453.38	7.0	0.77	3.33	0.00
110	April	20	11	0.00	592.88	12.0	0.74	3.33	0.00
110	April	20	12	0.00	662.62	16.5	0.66	3.33	0.00
110	April	20	13	0.00	662.62	19.0	0.49	4.72	0.07
110	April	20	14	0.00	627.75	20.0	0.34	5.56	0.16
110	April	20	15	0.00	558.00	20.0	0.30	5.00	0.26
110	April	20	16	0.00	488.25	21.0	0.30	4.72	0.32
110	April	20	17	0.00	383.63	21.0	0.28	4.44	0.44
110	April	20	18	0.00	244.12	20.5	0.28	3.61	0.41
110	April	20	19	0.00	156.94	20.5	0.28	1.67	0.39
110	April	20	20	0.00	52.31	19.0	0.27	0.28	0.36
110	April	20	21	0.00	0.00	16.5	0.27	1.11	0.33
110	April	20	22	0.00	0.00	14.5	0.28	1.39	0.30
110	April	20	23	0.00	0.00	13.5	0.34	1.39	0.28
110	April	20	24	0.00	0.00	11.5	0.45	1.94	0.25
111	April	21	1	0.00	0.00	6.0	0.45	1.39	0.22
111	April	21	2	0.00	0.00	1.0	0.50	0.56	0.19
111	April	21	3	0.00	0.00	-0.2	0.70	0.56	0.16
111	April	21	4	0.00	0.00	0.2	0.82	0.83	0.14
111	April	21	5	0.00	0.00	1.2	0.87	0.56	0.11
111	April	21	6	0.00	0.00	1.2	0.83	1.11	0.08
111	April	21	7	0.00	34.88	1.5	0.76	1.67	0.05
111	April	21	8	0.00	209.25	2.0	0.74	1.67	0.03
111	April	21	9	0.00	383.63	4.5	0.76	3.61	0.00
111	April	21	10	0.00	523.12	11.0	0.76	5.56	0.00
111	April	21	11	0.00	662.62	16.0	0.65	6.39	0.00
111	April	21	12	0.00	732.38	17.0	0.48	6.11	0.00
111	April	21	13	0.00	767.25	17.5	0.38	5.83	0.00
111	April	21	14	0.00	749.81	18.0	0.34	5.28	0.00
111	April	21	15	0.00	714.94	18.5	0.34	4.44	0.05

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
111	April	21	16	0.00	680.06	19.0	0.32	4.44	0.05
111	April	21	17	0.00	470.81	19.0	0.30	3.33	0.31
111	April	21	18	0.00	279.00	18.5	0.29	2.50	0.34
111	April	21	19	0.00	174.38	17.5	0.29	3.89	0.36
111	April	21	20	0.00	34.88	16.0	0.30	3.61	0.39
111	April	21	21	0.00	0.00	13.2	0.30	2.78	0.41
111	April	21	22	0.50	0.00	10.0	0.38	4.72	0.43
111	April	21	23	0.00	0.00	8.2	0.60	4.72	0.46
111	April	21	24	0.00	0.00	8.0	0.82	5.56	0.48
112	April	22	1	0.00	0.00	7.5	0.88	5.56	0.51
112	April	22	2	0.00	0.00	7.0	0.86	4.44	0.53
112	April	22	3	0.00	0.00	7.0	0.88	2.78	0.56
112	April	22	4	0.00	0.00	7.0	0.86	1.94	0.58
112	April	22	5	0.00	0.00	6.5	0.86	2.78	0.61
112	April	22	6	0.00	0.00	5.8	0.88	2.78	0.64
112	April	22	7	0.00	17.44	5.8	0.91	3.61	0.66
112	April	22	8	0.00	52.31	6.0	0.92	5.00	0.68
112	April	22	9	0.00	87.19	6.2	0.89	4.72	0.71
112	April	22	10	0.00	87.19	6.5	0.85	5.56	0.81
112	April	22	11	0.00	69.75	6.2	0.79	5.56	0.88
112	April	22	12	0.00	69.75	5.8	0.73	5.56	0.89
112	April	22	13	0.00	87.19	4.8	0.69	5.83	0.88
112	April	22	14	0.00	87.19	4.0	0.68	5.28	0.88
112	April	22	15	0.00	69.75	4.0	0.75	6.67	0.91
112	April	22	16	0.20	69.75	3.2	0.84	6.11	0.90
112	April	22	17	0.80	69.75	1.8	0.89	5.56	0.90
112	April	22	18	0.50	52.31	0.5	0.93	5.83	0.87
112	April	22	19	0.50	34.88	-0.5	0.95	5.00	0.84
112	April	22	20	0.30	17.44	-1.0	0.94	4.44	0.81
112	April	22	21	0.20	0.00	-1.0	0.92	3.61	0.78
112	April	22	22	0.00	0.00	-1.0	0.91	3.61	0.75
112	April	22	23	0.00	0.00	-1.0	0.90	3.33	0.72
112	April	22	24	0.00	0.00	-1.0	0.88	3.89	0.69
113	April	23	1	0.00	0.00	-1.0	0.88	3.33	0.66
113	April	23	2	0.00	0.00	-1.0	0.89	3.33	0.62
113	April	23	3	0.00	0.00	-1.2	0.89	3.33	0.59
113	April	23	4	0.00	0.00	-1.5	0.88	4.17	0.56
113	April	23	5	0.00	0.00	-1.5	0.86	3.89	0.53
113	April	23	6	0.00	0.00	-1.5	0.84	4.44	0.50
113	April	23	7	0.00	17.44	-1.5	0.84	4.17	0.47
113	April	23	8	0.00	87.19	-1.2	0.83	3.33	0.44
113	April	23	9	0.00	174.38	-0.5	0.81	2.22	0.41
113	April	23	10	0.00	313.87	0.5	0.77	3.06	0.31
113	April	23	11	0.00	383.63	1.2	0.72	4.17	0.33
113	April	23	12	0.00	418.50	1.8	0.67	4.44	0.37

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
113	April	23	13	0.00	383.63	2.2	0.62	4.72	0.46
113	April	23	14	0.00	244.12	2.5	0.58	3.89	0.67
113	April	23	15	0.00	244.12	3.0	0.56	3.89	0.67
113	April	23	16	0.00	244.12	3.5	0.57	3.61	0.66
113	April	23	17	0.00	191.81	3.8	0.56	3.33	0.72
113	April	23	18	0.00	191.81	4.0	0.56	3.06	0.67
113	April	23	19	0.00	174.38	3.5	0.65	3.06	0.63
113	April	23	20	0.00	69.75	2.0	0.75	2.78	0.58
113	April	23	21	0.00	0.00	0.8	0.82	2.22	0.54
113	April	23	22	0.00	0.00	0.2	0.86	0.83	0.49
113	April	23	23	0.00	0.00	-1.5	0.89	0.00	0.45
113	April	23	24	0.00	0.00	-3.2	0.89	1.11	0.40
114	April	24	1	0.00	0.00	-3.2	0.89	0.00	0.36
114	April	24	2	0.00	0.00	-4.0	0.89	0.00	0.32
114	April	24	3	0.00	0.00	-5.0	0.88	0.00	0.27
114	April	24	4	0.00	0.00	-5.0	0.88	0.00	0.22
114	April	24	5	0.00	0.00	-5.0	0.89	0.00	0.18
114	April	24	6	0.00	0.00	-4.8	0.89	0.00	0.14
114	April	24	7	0.00	34.88	-4.2	0.88	0.00	0.09
114	April	24	8	0.00	139.50	-2.8	0.88	0.28	0.05
114	April	24	9	0.00	313.87	0.0	0.84	0.83	0.00
114	April	24	10	0.00	488.25	2.8	0.65	1.94	0.00
114	April	24	11	0.00	523.12	4.5	0.47	2.50	0.09
114	April	24	12	0.00	418.50	6.0	0.43	2.78	0.37
114	April	24	13	0.00	348.75	6.5	0.41	1.94	0.51
114	April	24	14	0.00	383.63	6.5	0.41	2.22	0.49
114	April	24	15	0.00	453.37	7.0	0.40	1.94	0.40
114	April	24	16	0.00	453.37	8.0	0.39	2.22	0.37
114	April	24	17	0.00	313.87	8.5	0.37	2.50	0.54
114	April	24	18	0.00	174.38	8.5	0.34	1.94	0.51
114	April	24	19	0.00	122.06	8.2	0.34	3.06	0.47
114	April	24	20	0.00	69.75	7.5	0.39	1.94	0.44
114	April	24	21	0.00	17.44	6.0	0.47	1.39	0.41
114	April	24	22	0.00	0.00	2.8	0.58	1.67	0.37
114	April	24	23	0.00	0.00	-0.2	0.72	1.11	0.34
114	April	24	24	0.00	0.00	-1.5	0.83	1.94	0.30
115	April	25	1	0.00	0.00	-1.8	0.86	1.94	0.27
115	April	25	2	0.00	0.00	-2.5	0.85	2.22	0.24
115	April	25	3	0.00	0.00	-3.8	0.88	1.94	0.20
115	April	25	4	0.00	0.00	-4.8	0.89	1.94	0.17
115	April	25	5	0.00	0.00	-5.2	0.90	1.94	0.14
115	April	25	6	0.00	0.00	-5.8	0.90	1.39	0.10
115	April	25	7	0.00	34.88	-5.5	0.89	1.94	0.07
115	April	25	8	0.00	174.38	-3.5	0.89	1.67	0.03
115	April	25	9	0.00	348.75	-0.2	0.79	2.22	0.00

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
115	April	25	10	0.00	488.25	3.2	0.62	2.78	0.00
115	April	25	11	0.00	592.88	6.5	0.45	2.22	0.00
115	April	25	12	0.00	662.62	9.0	0.31	2.78	0.00
115	April	25	13	0.00	714.94	10.0	0.25	2.22	0.00
115	April	25	14	0.00	749.81	10.2	0.21	3.06	0.00
115	April	25	15	0.00	784.69	10.8	0.16	3.33	0.00
115	April	25	16	0.00	749.81	11.5	0.14	3.06	0.00
115	April	25	17	0.00	592.88	11.8	0.11	3.61	0.13
115	April	25	18	0.00	418.50	11.2	0.11	3.61	0.15
115	April	25	19	0.00	279.00	10.8	0.10	3.61	0.17
115	April	25	20	0.00	139.50	10.0	0.11	2.50	0.18
115	April	25	21	0.00	34.88	8.2	0.16	1.67	0.20
115	April	25	22	0.00	0.00	6.5	0.24	1.94	0.22
115	April	25	23	0.00	0.00	5.5	0.31	2.22	0.23
115	April	25	24	0.00	0.00	4.8	0.36	2.22	0.25
116	April	26	1	0.00	0.00	3.2	0.43	2.50	0.27
116	April	26	2	0.00	0.00	1.2	0.55	2.50	0.29
116	April	26	3	0.00	0.00	0.5	0.65	2.50	0.30
116	April	26	4	0.00	0.00	0.5	0.68	2.22	0.32
116	April	26	5	0.00	0.00	0.5	0.70	2.50	0.34
116	April	26	6	0.00	0.00	0.8	0.71	2.50	0.36
116	April	26	7	0.00	34.88	1.2	0.72	3.06	0.38
116	April	26	8	0.00	104.63	1.8	0.70	3.33	0.39
116	April	26	9	0.00	174.38	2.5	0.65	4.17	0.41
116	April	26	10	0.00	279.00	4.0	0.58	4.72	0.38
116	April	26	11	0.00	383.63	5.5	0.51	5.28	0.33
116	April	26	12	0.00	418.50	7.0	0.44	5.00	0.37
116	April	26	13	0.00	383.63	8.0	0.41	3.89	0.46
116	April	26	14	0.00	313.88	8.0	0.41	3.89	0.58
116	April	26	15	0.00	383.63	8.2	0.45	3.33	0.49
116	April	26	16	0.00	418.50	8.8	0.46	1.94	0.41
116	April	26	17	0.00	313.88	9.2	0.42	1.94	0.54
116	April	26	18	0.00	348.75	9.8	0.38	1.67	0.52
116	April	26	19	0.00	279.00	9.8	0.37	2.78	0.51
116	April	26	20	0.00	104.63	9.2	0.39	2.78	0.49
116	April	26	21	0.00	34.88	8.5	0.40	2.22	0.48
116	April	26	22	0.00	0.00	7.0	0.40	1.94	0.46
116	April	26	23	0.00	0.00	5.0	0.50	1.94	0.45
116	April	26	24	0.00	0.00	3.0	0.70	1.67	0.43
117	April	27	1	0.00	0.00	1.0	0.84	1.67	0.42
117	April	27	2	0.00	0.00	-0.5	0.90	1.67	0.40
117	April	27	3	0.00	0.00	-0.8	0.89	2.22	0.38
117	April	27	4	0.00	0.00	-1.0	0.86	2.22	0.37
117	April	27	5	0.00	0.00	-2.0	0.87	2.22	0.35
117	April	27	6	0.00	0.00	-3.8	0.89	1.67	0.34

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
117	April	27	7	0.00	34.88	-3.5	0.92	1.67	0.32
117	April	27	8	0.00	104.63	0.0	0.81	1.94	0.31
117	April	27	9	0.00	209.25	3.5	0.61	3.06	0.29
117	April	27	10	0.00	383.63	6.5	0.47	1.39	0.15
117	April	27	11	0.00	558.00	10.2	0.39	0.83	0.03
117	April	27	12	0.00	662.62	12.2	0.33	2.22	0.00
117	April	27	13	0.00	732.38	12.0	0.31	2.22	0.00
117	April	27	14	0.00	749.81	12.5	0.29	2.78	0.00
117	April	27	15	0.00	714.94	13.2	0.28	2.22	0.05
117	April	27	16	0.00	627.75	13.5	0.27	1.94	0.12
117	April	27	17	0.00	453.38	13.2	0.26	1.94	0.33
117	April	27	18	0.00	313.88	13.0	0.25	1.94	0.33
117	April	27	19	0.00	174.38	12.8	0.25	2.50	0.33
117	April	27	20	0.00	52.31	12.0	0.27	1.67	0.32
117	April	27	21	0.00	17.44	9.2	0.34	1.39	0.32
117	April	27	22	0.00	0.00	6.0	0.45	1.67	0.32
117	April	27	23	0.00	0.00	4.2	0.53	1.67	0.32
117	April	27	24	0.00	0.00	2.2	0.61	1.67	0.31
118	April	28	1	0.00	0.00	0.0	0.72	1.39	0.31
118	April	28	2	0.00	0.00	-1.5	0.80	1.11	0.31
118	April	28	3	0.00	0.00	-2.5	0.88	0.28	0.30
118	April	28	4	0.00	0.00	-3.0	0.90	0.00	0.30
118	April	28	5	0.00	0.00	-3.8	0.92	1.11	0.30
118	April	28	6	0.00	0.00	-4.2	0.90	1.67	0.30
118	April	28	7	0.00	17.44	-2.5	0.89	1.67	0.29
118	April	28	8	0.00	87.19	1.0	0.76	1.67	0.29
118	April	28	9	0.00	209.25	5.5	0.53	1.94	0.29
118	April	28	10	0.00	348.75	9.5	0.38	1.94	0.23
118	April	28	11	0.00	488.25	11.5	0.29	1.39	0.15
118	April	28	12	0.00	610.31	12.8	0.27	1.94	0.08
118	April	28	13	0.00	697.50	13.8	0.24	2.78	0.02
118	April	28	14	0.00	732.38	14.5	0.23	1.39	0.02
118	April	28	15	0.00	732.38	15.5	0.21	2.22	0.02
118	April	28	16	0.00	714.94	16.2	0.19	3.33	0.00
118	April	28	17	0.00	645.19	16.5	0.19	2.78	0.05
118	April	28	18	0.00	470.81	16.2	0.19	3.61	0.06
118	April	28	19	0.00	279.00	15.8	0.19	2.78	0.07
118	April	28	20	0.00	139.50	14.2	0.21	3.06	0.09
118	April	28	21	0.00	34.88	10.5	0.28	1.94	0.10
118	April	28	22	0.00	0.00	6.0	0.42	1.94	0.11
118	April	28	23	0.00	0.00	2.5	0.66	1.67	0.12
118	April	28	24	0.00	0.00	0.5	0.78	0.56	0.13
119	April	29	1	0.00	0.00	0.0	0.75	0.00	0.15
119	April	29	2	0.00	0.00	-0.5	0.77	1.94	0.16
119	April	29	3	0.00	0.00	-1.5	0.83	2.50	0.17

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
119	April	29	4	0.00	0.00	-2.5	0.90	2.22	0.18
119	April	29	5	0.00	0.00	-3.5	0.92	2.78	0.19
119	April	29	6	0.00	0.00	-4.2	0.93	2.50	0.20
119	April	29	7	0.00	17.44	-2.8	0.84	1.94	0.22
119	April	29	8	0.00	87.19	2.0	0.64	3.06	0.23
119	April	29	9	0.00	226.69	7.5	0.45	2.78	0.24
119	April	29	10	0.00	401.06	11.0	0.36	1.94	0.12
119	April	29	11	0.00	523.12	12.8	0.30	2.22	0.09
119	April	29	12	0.00	610.31	14.2	0.26	3.33	0.08
119	April	29	13	0.00	697.50	15.2	0.21	3.33	0.02
119	April	29	14	0.00	732.38	16.0	0.16	3.06	0.02
119	April	29	15	0.00	732.38	16.8	0.12	3.06	0.02
119	April	29	16	0.00	714.94	17.0	0.09	3.33	0.00
119	April	29	17	0.00	662.62	16.8	0.07	4.44	0.03
119	April	29	18	0.00	558.00	16.2	0.07	3.33	0.03
119	April	29	19	0.00	383.63	15.0	0.08	3.33	0.03
119	April	29	20	0.00	209.25	12.5	0.09	3.06	0.02
119	April	29	21	0.00	87.19	9.2	0.14	1.94	0.02
119	April	29	22	0.00	17.44	7.2	0.21	2.22	0.02
119	April	29	23	0.00	0.00	6.5	0.28	2.50	0.02
119	April	29	24	0.00	0.00	5.5	0.33	2.50	0.02
120	April	30	1	0.00	0.00	5.0	0.38	2.78	0.01
120	April	30	2	0.00	0.00	5.0	0.41	2.50	0.01
120	April	30	3	0.00	0.00	4.2	0.46	2.78	0.01
120	April	30	4	0.00	0.00	3.5	0.51	2.78	0.01
120	April	30	5	0.00	0.00	2.8	0.52	2.78	0.01
120	April	30	6	0.00	17.44	2.5	0.54	2.78	0.01
120	April	30	7	0.00	52.31	4.0	0.54	2.78	0.00
120	April	30	8	0.00	156.94	6.0	0.49	3.33	0.00
120	April	30	9	0.00	366.19	9.5	0.40	4.44	0.00
120	April	30	10	0.00	558.00	12.8	0.30	4.17	0.00
120	April	30	11	0.00	662.62	14.2	0.23	5.00	0.00
120	April	30	12	0.00	714.94	15.5	0.20	5.28	0.00
120	April	30	13	0.00	749.81	16.2	0.17	5.56	0.00
120	April	30	14	0.00	767.25	16.8	0.16	4.72	0.00
120	April	30	15	0.00	749.81	17.2	0.15	3.89	0.00
120	April	30	16	0.00	697.50	17.8	0.15	5.00	0.02
120	April	30	17	0.00	540.56	17.8	0.14	3.61	0.21
120	April	30	18	0.00	348.75	17.2	0.15	5.00	0.20
120	April	30	19	0.00	191.81	15.5	0.16	4.17	0.18
120	April	30	20	0.00	69.75	13.5	0.20	3.89	0.17
120	April	30	21	0.00	17.44	12.0	0.23	2.78	0.16
120	April	30	22	0.00	0.00	10.0	0.29	2.50	0.14
120	April	30	23	0.00	0.00	8.0	0.36	3.33	0.13
120	April	30	24	0.00	0.00	7.0	0.42	3.06	0.12

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
121	May	1	1	0.00	0.00	6.5	0.42	2.22	0.10
121	May	1	2	0.00	0.00	5.0	0.44	2.50	0.09
121	May	1	3	0.00	0.00	3.2	0.52	2.50	0.08
121	May	1	4	0.00	0.00	1.8	0.61	2.50	0.07
121	May	1	5	0.00	0.00	1.0	0.68	2.78	0.05
121	May	1	6	0.00	0.00	0.8	0.71	3.33	0.04
121	May	1	7	0.00	34.88	2.5	0.71	3.33	0.03
121	May	1	8	0.00	104.63	5.8	0.65	4.17	0.01
121	May	1	9	0.00	313.87	9.2	0.55	3.89	0.00
121	May	1	10	0.00	453.37	12.8	0.42	4.44	0.00
121	May	1	11	0.00	348.75	13.8	0.33	4.17	0.43
121	May	1	12	0.00	313.88	14.2	0.32	5.00	0.54
121	May	1	13	0.00	418.50	15.2	0.30	3.89	0.43
121	May	1	14	0.00	453.37	15.8	0.29	3.89	0.42
121	May	1	15	0.00	348.75	15.8	0.28	3.61	0.56
121	May	1	16	0.00	261.56	15.8	0.27	1.67	0.64
121	May	1	17	0.00	261.56	16.0	0.26	2.22	0.62
121	May	1	18	0.00	209.25	15.8	0.26	1.39	0.61
121	May	1	19	0.00	104.63	15.2	0.27	1.67	0.60
121	May	1	20	0.00	52.31	14.0	0.31	1.39	0.59
121	May	1	21	0.00	17.44	11.5	0.36	0.56	0.58
121	May	1	22	0.00	0.00	9.5	0.43	0.83	0.57
121	May	1	23	0.00	0.00	9.0	0.61	0.00	0.56
121	May	1	24	0.00	0.00	9.0	0.78	0.28	0.55
122	May	2	1	0.00	0.00	9.0	0.77	5.00	0.54
122	May	2	2	0.00	0.00	8.8	0.72	5.56	0.52
122	May	2	3	0.00	0.00	8.0	0.71	6.39	0.51
122	May	2	4	0.00	0.00	7.2	0.71	4.44	0.50
122	May	2	5	0.00	0.00	7.0	0.69	4.17	0.49
122	May	2	6	0.00	0.00	6.5	0.72	4.44	0.48
122	May	2	7	0.00	34.88	5.8	0.75	5.00	0.47
122	May	2	8	0.00	104.63	5.5	0.76	6.39	0.46
122	May	2	9	0.00	209.25	5.8	0.73	6.11	0.45
122	May	2	10	0.00	296.44	7.0	0.69	5.83	0.43
122	May	2	11	0.00	331.31	8.2	0.65	5.56	0.46
122	May	2	12	0.00	313.88	8.8	0.63	5.56	0.54
122	May	2	13	0.00	348.75	9.5	0.61	5.56	0.52
122	May	2	14	0.00	348.75	10.5	0.59	4.44	0.56
122	May	2	15	0.00	209.25	9.5	0.74	4.17	0.73
122	May	2	16	1.00	139.50	8.2	0.85	4.72	0.81
122	May	2	17	0.00	209.25	9.2	0.75	4.17	0.69
122	May	2	18	0.00	261.56	10.5	0.65	2.78	0.66
122	May	2	19	0.00	226.69	10.8	0.57	2.78	0.62
122	May	2	20	0.00	139.50	10.2	0.57	1.94	0.59
122	May	2	21	0.00	34.88	9.0	0.64	1.39	0.55

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
122	May	2	22	0.00	0.00	6.8	0.77	1.39	0.52
122	May	2	23	0.00	0.00	3.8	0.90	1.67	0.48
122	May	2	24	0.00	0.00	1.5	0.94	1.11	0.45
123	May	3	1	0.00	0.00	0.0	0.94	0.28	0.41
123	May	3	2	0.00	0.00	-1.0	0.94	0.28	0.38
123	May	3	3	0.00	0.00	-1.0	0.93	0.83	0.35
123	May	3	4	0.00	0.00	-1.5	0.93	0.83	0.31
123	May	3	5	0.00	0.00	-2.2	0.92	1.39	0.28
123	May	3	6	0.00	0.00	-2.8	0.91	1.11	0.24
123	May	3	7	0.00	34.88	-2.0	0.90	1.67	0.21
123	May	3	8	0.00	156.94	0.5	0.90	2.50	0.17
123	May	3	9	0.00	331.31	4.8	0.79	3.33	0.14
123	May	3	10	0.00	453.37	8.8	0.58	4.72	0.13
123	May	3	11	0.00	383.63	12.5	0.47	4.72	0.37
123	May	3	12	0.00	383.63	15.5	0.43	5.83	0.44
123	May	3	13	0.00	523.12	16.5	0.38	5.83	0.29
123	May	3	14	0.00	592.88	18.0	0.34	6.94	0.24
123	May	3	15	0.00	697.50	19.0	0.30	8.06	0.11
123	May	3	16	0.00	662.62	15.0	0.53	7.22	0.10
123	May	3	17	0.00	348.75	12.0	0.71	6.67	0.49
123	May	3	18	0.00	174.38	13.0	0.57	7.22	0.49
123	May	3	19	0.00	209.25	14.0	0.65	5.00	0.48
123	May	3	20	0.00	139.50	13.8	0.77	6.67	0.48
123	May	3	21	0.80	52.31	11.2	0.73	6.39	0.48
123	May	3	22	0.00	17.44	9.5	0.74	6.11	0.48
123	May	3	23	0.00	0.00	8.8	0.75	5.00	0.47
123	May	3	24	0.00	0.00	8.2	0.76	5.56	0.47
124	May	4	1	0.00	0.00	7.2	0.83	1.94	0.47
124	May	4	2	0.00	0.00	6.2	0.90	3.33	0.47
124	May	4	3	0.00	0.00	5.0	0.92	2.78	0.47
124	May	4	4	0.00	0.00	3.5	0.93	2.78	0.46
124	May	4	5	0.00	0.00	3.0	0.92	1.94	0.46
124	May	4	6	0.00	0.00	3.0	0.91	0.28	0.46
124	May	4	7	0.00	34.88	3.2	0.92	0.56	0.46
124	May	4	8	0.00	139.50	4.2	0.90	1.39	0.45
124	May	4	9	0.00	209.25	6.0	0.81	1.94	0.45
124	May	4	10	0.00	261.56	7.5	0.71	2.50	0.50
124	May	4	11	0.00	226.69	8.5	0.63	4.44	0.63
124	May	4	12	0.00	139.50	8.0	0.65	3.89	0.79
124	May	4	13	0.00	209.25	7.8	0.65	5.83	0.71
124	May	4	14	0.00	279.00	9.0	0.58	6.67	0.64
124	May	4	15	0.00	418.50	11.0	0.46	7.22	0.47
124	May	4	16	0.00	488.25	11.8	0.32	7.22	0.33
124	May	4	17	0.00	348.75	12.2	0.28	6.67	0.49
124	May	4	18	0.00	279.00	12.8	0.28	7.50	0.46

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
124	May	4	19	0.00	244.12	11.8	0.31	7.22	0.44
124	May	4	20	0.00	139.50	10.5	0.36	5.83	0.41
124	May	4	21	0.00	34.88	7.8	0.42	3.89	0.39
124	May	4	22	0.00	0.00	4.5	0.50	2.22	0.36
124	May	4	23	0.00	0.00	1.5	0.59	2.22	0.34
124	May	4	24	0.00	0.00	-1.0	0.65	1.94	0.31
125	May	5	1	0.00	0.00	-1.5	0.66	2.22	0.29
125	May	5	2	0.00	0.00	-1.0	0.66	2.22	0.27
125	May	5	3	0.00	0.00	-1.0	0.66	1.94	0.24
125	May	5	4	0.00	0.00	-1.5	0.68	2.78	0.21
125	May	5	5	0.00	0.00	-1.0	0.66	3.06	0.19
125	May	5	6	0.00	0.00	0.2	0.60	3.06	0.16
125	May	5	7	0.00	52.31	1.2	0.57	4.17	0.14
125	May	5	8	0.00	191.81	4.0	0.53	5.83	0.11
125	May	5	9	0.00	348.75	7.5	0.45	6.11	0.09
125	May	5	10	0.00	488.25	10.2	0.39	6.94	0.07
125	May	5	11	0.00	592.88	12.8	0.35	7.50	0.03
125	May	5	12	0.00	662.62	15.2	0.33	7.78	0.03
125	May	5	13	0.00	697.50	17.0	0.30	7.50	0.05
125	May	5	14	0.00	697.50	18.2	0.28	8.06	0.11
125	May	5	15	0.00	662.62	20.0	0.26	8.06	0.16
125	May	5	16	0.00	592.88	21.2	0.22	6.67	0.19
125	May	5	17	0.00	418.50	21.8	0.19	6.11	0.38
125	May	5	18	0.00	209.25	21.0	0.20	5.83	0.37
125	May	5	19	0.00	139.50	19.8	0.22	5.83	0.35
125	May	5	20	0.00	87.19	18.5	0.26	5.00	0.34
125	May	5	21	0.00	17.44	16.8	0.31	3.61	0.33
125	May	5	22	0.00	0.00	15.0	0.37	3.89	0.32
125	May	5	23	0.00	0.00	13.5	0.44	4.44	0.30
125	May	5	24	0.00	0.00	12.0	0.51	4.72	0.29
126	May	6	1	0.00	0.00	10.5	0.55	3.89	0.28
126	May	6	2	0.00	0.00	9.5	0.60	3.61	0.27
126	May	6	3	0.00	0.00	9.5	0.61	2.50	0.26
126	May	6	4	0.00	0.00	9.5	0.58	1.67	0.24
126	May	6	5	0.00	0.00	8.0	0.59	2.78	0.23
126	May	6	6	0.00	17.44	7.5	0.62	0.56	0.22
126	May	6	7	0.00	69.75	9.0	0.64	0.56	0.20
126	May	6	8	0.00	156.94	12.0	0.55	2.78	0.19
126	May	6	9	0.00	313.87	16.0	0.41	3.61	0.18
126	May	6	10	0.00	453.37	18.5	0.35	5.56	0.13
126	May	6	11	0.00	523.12	19.8	0.33	5.56	0.14
126	May	6	12	0.00	592.88	21.0	0.30	5.28	0.13
126	May	6	13	0.00	558.00	21.5	0.28	5.83	0.24
126	May	6	14	0.00	558.00	21.8	0.27	6.67	0.29
126	May	6	15	0.00	523.12	21.5	0.28	6.39	0.33

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
126	May	6	16	0.00	418.50	22.0	0.28	5.56	0.43
126	May	6	17	0.00	383.63	22.0	0.28	4.17	0.44
126	May	6	18	0.00	313.88	21.0	0.29	4.72	0.42
126	May	6	19	0.00	209.25	20.0	0.30	6.39	0.40
126	May	6	20	0.00	87.19	17.2	0.41	5.83	0.37
126	May	6	21	0.00	17.44	14.5	0.54	2.78	0.35
126	May	6	22	0.00	0.00	13.2	0.62	0.28	0.33
126	May	6	23	0.00	0.00	12.0	0.76	0.00	0.31
126	May	6	24	0.00	0.00	11.0	0.85	0.56	0.29
127	May	7	1	0.00	0.00	10.5	0.88	1.94	0.27
127	May	7	2	0.00	0.00	10.0	0.88	0.56	0.24
127	May	7	3	0.00	0.00	9.5	0.89	0.56	0.22
127	May	7	4	0.00	0.00	8.8	0.86	0.56	0.20
127	May	7	5	0.50	0.00	8.0	0.83	1.39	0.18
127	May	7	6	0.00	0.00	7.2	0.85	0.56	0.16
127	May	7	7	0.00	34.88	8.2	0.80	1.11	0.13
127	May	7	8	0.00	174.38	10.5	0.70	3.06	0.11
127	May	7	9	0.00	348.75	12.2	0.60	4.44	0.09
127	May	7	10	0.00	488.25	14.2	0.51	4.17	0.07
127	May	7	11	0.00	592.88	16.2	0.43	5.83	0.03
127	May	7	12	0.00	523.12	16.5	0.41	7.22	0.23
127	May	7	13	0.00	488.25	17.0	0.41	6.67	0.33
127	May	7	14	0.00	558.00	17.2	0.42	6.39	0.29
127	May	7	15	0.00	627.75	17.8	0.39	6.39	0.20
127	May	7	16	0.00	558.00	18.8	0.33	5.28	0.24
127	May	7	17	0.00	383.63	19.2	0.32	5.28	0.44
127	May	7	18	0.00	279.00	19.5	0.29	4.17	0.42
127	May	7	19	0.00	139.50	18.0	0.29	4.17	0.40
127	May	7	20	0.00	52.31	16.5	0.40	4.44	0.37
127	May	7	21	0.00	17.44	14.5	0.53	1.11	0.35
127	May	7	22	0.00	0.00	12.0	0.64	1.39	0.33
127	May	7	23	0.00	0.00	10.5	0.75	1.94	0.31
127	May	7	24	0.00	0.00	9.2	0.80	1.39	0.29
128	May	8	1	0.00	0.00	6.5	0.88	1.11	0.27
128	May	8	2	0.00	0.00	4.2	0.91	1.11	0.24
128	May	8	3	0.00	0.00	3.5	0.92	1.39	0.22
128	May	8	4	0.00	0.00	3.0	0.94	1.11	0.20
128	May	8	5	0.00	0.00	3.0	0.94	1.11	0.18
128	May	8	6	0.00	0.00	2.5	0.93	1.11	0.16
128	May	8	7	0.00	69.75	3.5	0.89	0.56	0.13
128	May	8	8	0.00	209.25	7.5	0.75	0.28	0.11
128	May	8	9	0.00	348.75	12.5	0.57	1.94	0.09
128	May	8	10	0.00	488.25	16.8	0.42	1.94	0.07
128	May	8	11	0.00	592.88	20.2	0.30	1.94	0.03
128	May	8	12	0.00	732.38	21.5	0.22	2.22	0.00

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
128	May	8	13	0.00	592.88	20.5	0.19	1.94	0.19
128	May	8	14	0.00	383.63	20.8	0.18	1.39	0.51
128	May	8	15	0.00	558.00	22.2	0.16	2.78	0.29
128	May	8	16	0.00	592.88	22.8	0.15	1.39	0.19
128	May	8	17	0.00	383.63	22.2	0.15	2.22	0.44
128	May	8	18	0.00	279.00	22.5	0.15	1.94	0.42
128	May	8	19	0.00	244.12	22.5	0.15	2.22	0.41
128	May	8	20	0.00	139.50	21.2	0.17	1.11	0.39
128	May	8	21	0.00	34.88	18.8	0.20	0.56	0.38
128	May	8	22	0.00	0.00	16.0	0.26	1.11	0.36
128	May	8	23	0.00	0.00	15.0	0.33	1.94	0.34
128	May	8	24	0.00	0.00	14.5	0.39	2.50	0.33
129	May	9	1	0.00	0.00	14.0	0.42	2.50	0.31
129	May	9	2	0.00	0.00	13.2	0.45	2.22	0.29
129	May	9	3	0.00	0.00	12.2	0.46	2.22	0.28
129	May	9	4	0.00	0.00	11.5	0.49	2.50	0.26
129	May	9	5	0.00	0.00	9.5	0.54	2.78	0.24
129	May	9	6	0.00	0.00	8.2	0.62	3.33	0.23
129	May	9	7	0.00	34.88	9.2	0.66	3.33	0.21
129	May	9	8	0.00	139.50	12.5	0.62	4.44	0.20
129	May	9	9	0.00	313.87	17.0	0.50	5.28	0.18
129	May	9	10	0.00	453.37	19.8	0.38	5.83	0.13
129	May	9	11	0.00	558.00	21.2	0.33	7.50	0.09
129	May	9	12	0.00	662.62	22.5	0.29	8.06	0.03
129	May	9	13	0.00	732.38	23.0	0.27	8.33	0.00
129	May	9	14	0.00	732.38	23.2	0.26	8.33	0.07
129	May	9	15	0.00	680.06	23.8	0.24	8.33	0.13
129	May	9	16	0.00	627.75	24.0	0.23	8.06	0.14
129	May	9	17	0.00	540.56	24.2	0.24	7.78	0.21
129	May	9	18	0.00	383.63	24.0	0.26	7.22	0.23
129	May	9	19	0.00	244.12	23.0	0.28	7.50	0.24
129	May	9	20	0.00	156.94	22.0	0.31	5.00	0.26
129	May	9	21	0.00	69.75	19.5	0.39	3.61	0.27
129	May	9	22	0.00	17.44	17.2	0.47	3.33	0.29
129	May	9	23	0.00	0.00	17.0	0.51	3.33	0.30
129	May	9	24	0.00	0.00	17.0	0.54	4.17	0.32
130	May	10	1	0.00	0.00	16.0	0.57	4.44	0.33
130	May	10	2	0.00	0.00	14.2	0.60	4.44	0.34
130	May	10	3	0.00	0.00	12.8	0.64	5.00	0.36
130	May	10	4	0.00	0.00	11.5	0.67	4.72	0.38
130	May	10	5	0.00	0.00	10.8	0.71	5.28	0.39
130	May	10	6	0.00	0.00	10.5	0.74	4.44	0.41
130	May	10	7	0.00	17.44	12.2	0.72	5.56	0.42
130	May	10	8	0.00	87.19	14.5	0.67	6.39	0.43
130	May	10	9	0.00	209.25	15.5	0.66	6.67	0.45

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
130	May	10	10	0.00	418.50	17.5	0.63	5.83	0.20
130	May	10	11	0.00	523.12	20.5	0.56	6.94	0.14
130	May	10	12	0.00	523.12	21.5	0.52	6.67	0.23
130	May	10	13	0.00	680.06	22.8	0.47	8.61	0.07
130	May	10	14	0.00	680.06	24.8	0.43	9.44	0.13
130	May	10	15	0.00	575.44	25.8	0.39	8.33	0.27
130	May	10	16	0.00	575.44	26.8	0.38	7.78	0.21
130	May	10	17	0.00	418.50	27.2	0.36	8.06	0.38
130	May	10	18	0.00	279.00	27.2	0.34	6.67	0.41
130	May	10	19	0.00	209.25	26.5	0.33	6.67	0.43
130	May	10	20	0.00	87.19	25.5	0.32	5.56	0.46
130	May	10	21	0.00	17.44	21.5	0.48	5.00	0.49
130	May	10	22	0.00	0.00	16.5	0.71	5.28	0.52
130	May	10	23	0.00	0.00	14.0	0.80	4.72	0.54
130	May	10	24	0.00	0.00	12.2	0.89	5.56	0.57
131	May	11	1	0.00	0.00	11.2	0.92	7.50	0.60
131	May	11	2	0.00	0.00	10.8	0.92	6.94	0.63
131	May	11	3	0.00	0.00	10.2	0.91	6.39	0.66
131	May	11	4	0.00	0.00	9.8	0.89	6.11	0.68
131	May	11	5	0.00	0.00	9.2	0.89	6.39	0.71
131	May	11	6	0.00	0.00	9.0	0.89	6.11	0.74
131	May	11	7	0.00	17.44	9.0	0.86	6.11	0.76
131	May	11	8	0.00	52.31	9.0	0.85	6.39	0.79
131	May	11	9	0.00	69.75	9.0	0.81	6.67	0.82
131	May	11	10	0.00	69.75	9.0	0.77	7.22	0.87
131	May	11	11	0.00	209.25	9.0	0.77	5.83	0.66
131	May	11	12	0.00	523.12	10.0	0.72	6.11	0.23
131	May	11	13	0.00	627.75	12.8	0.57	5.83	0.14
131	May	11	14	0.00	662.62	15.2	0.45	4.72	0.16
131	May	11	15	0.00	627.75	16.8	0.38	5.28	0.20
131	May	11	16	0.00	383.63	17.2	0.34	4.17	0.48
131	May	11	17	0.00	174.38	16.8	0.34	3.89	0.74
131	May	11	18	0.00	52.31	15.8	0.36	3.06	0.72
131	May	11	19	0.00	34.88	13.0	0.59	2.78	0.71
131	May	11	20	0.00	17.44	11.0	0.74	2.50	0.69
131	May	11	21	0.00	0.00	10.5	0.70	5.56	0.68
131	May	11	22	0.00	0.00	8.8	0.79	5.83	0.67
131	May	11	23	0.00	0.00	7.0	0.89	7.22	0.65
131	May	11	24	0.00	0.00	6.2	0.92	6.11	0.64
132	May	12	1	0.00	0.00	5.2	0.94	6.39	0.62
132	May	12	2	0.00	0.00	4.5	0.96	6.39	0.60
132	May	12	3	0.00	0.00	4.5	0.97	5.83	0.59
132	May	12	4	0.00	0.00	4.5	0.96	5.56	0.57
132	May	12	5	0.00	0.00	4.5	0.93	7.78	0.56
132	May	12	6	0.00	17.44	4.8	0.89	6.94	0.54

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
132	May	12	7	0.00	17.44	4.8	0.89	6.67	0.53
132	May	12	8	0.00	69.75	4.8	0.88	6.11	0.52
132	May	12	9	0.00	191.81	6.5	0.79	5.00	0.50
132	May	12	10	0.00	331.31	8.8	0.67	5.83	0.37
132	May	12	11	0.00	523.12	10.2	0.56	6.94	0.14
132	May	12	12	0.00	558.00	11.5	0.49	6.94	0.18
132	May	12	13	0.00	523.12	12.5	0.42	5.56	0.29
132	May	12	14	0.00	592.88	13.8	0.34	5.83	0.24
132	May	12	15	0.00	592.88	14.8	0.29	5.00	0.24
132	May	12	16	0.00	627.75	15.0	0.27	5.28	0.14
132	May	12	17	0.00	592.88	15.0	0.24	4.44	0.13
132	May	12	18	0.00	418.50	14.5	0.23	4.72	0.16
132	May	12	19	0.00	279.00	13.8	0.23	4.44	0.19
132	May	12	20	0.00	139.50	13.2	0.25	3.89	0.22
132	May	12	21	0.00	34.88	12.0	0.27	1.67	0.24
132	May	12	22	0.00	0.00	9.0	0.32	0.00	0.27
132	May	12	23	0.00	0.00	6.5	0.41	0.00	0.30
132	May	12	24	0.00	0.00	5.2	0.50	0.56	0.33
133	May	13	1	0.00	0.00	4.0	0.57	1.39	0.36
133	May	13	2	0.00	0.00	3.2	0.62	0.83	0.39
133	May	13	3	0.00	0.00	3.0	0.64	1.11	0.42
133	May	13	4	0.00	0.00	2.5	0.66	1.39	0.45
133	May	13	5	0.00	0.00	1.8	0.69	1.67	0.47
133	May	13	6	0.00	6.98	1.2	0.73	1.94	0.50
133	May	13	7	0.00	24.41	3.0	0.71	1.94	0.53
133	May	13	8	0.00	69.75	6.5	0.59	3.33	0.56
133	May	13	9	0.00	156.94	10.0	0.47	5.28	0.59
133	May	13	10	0.00	313.87	13.0	0.35	5.28	0.40
133	May	13	11	0.00	523.12	14.0	0.28	6.39	0.14
133	May	13	12	0.00	453.38	14.5	0.25	6.11	0.33
133	May	13	13	0.00	453.38	15.2	0.24	6.11	0.38
133	May	13	14	0.00	558.00	15.8	0.23	5.83	0.29
133	May	13	15	0.00	558.00	16.2	0.21	5.56	0.29
133	May	13	16	0.00	645.19	16.8	0.20	5.83	0.12
133	May	13	17	0.00	575.44	17.0	0.19	5.00	0.15
133	May	13	18	0.00	418.50	16.5	0.20	4.17	0.18
133	May	13	19	0.00	261.56	15.8	0.21	3.89	0.21
133	May	13	20	0.00	122.06	15.0	0.21	3.61	0.24
133	May	13	21	0.00	34.88	13.0	0.24	1.94	0.27
133	May	13	22	0.00	0.00	9.2	0.30	0.28	0.30
133	May	13	23	0.00	0.00	7.8	0.49	1.39	0.33
133	May	13	24	0.00	0.00	8.2	0.66	3.33	0.36
134	May	14	1	0.00	0.00	7.5	0.72	3.06	0.40
134	May	14	2	0.00	0.00	6.8	0.78	2.50	0.43
134	May	14	3	0.00	0.00	6.7	0.80	2.22	0.46

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
134	May	14	4	0.00	0.00	6.8	0.81	1.39	0.49
134	May	14	5	0.00	0.00	6.7	0.81	0.83	0.52
134	May	14	6	0.00	0.00	6.2	0.82	1.39	0.55
134	May	14	7	0.00	34.88	6.2	0.84	0.28	0.58
134	May	14	8	0.00	69.75	6.8	0.81	0.00	0.61
134	May	14	9	0.00	139.50	7.8	0.77	0.00	0.64
134	May	14	10	0.00	313.87	10.0	0.70	1.39	0.40
134	May	14	11	0.00	523.12	12.8	0.56	2.50	0.14
134	May	14	12	0.00	627.75	14.5	0.46	2.78	0.08
134	May	14	13	0.00	714.94	15.8	0.42	3.06	0.02
134	May	14	14	0.00	540.56	17.0	0.38	3.61	0.31
134	May	14	15	0.00	383.63	16.8	0.36	3.61	0.51
134	May	14	16	0.00	383.63	16.5	0.36	2.78	0.48
134	May	14	17	0.00	226.69	16.5	0.35	3.89	0.67
134	May	14	18	0.00	226.69	16.5	0.35	3.33	0.65
134	May	14	19	0.00	174.38	16.5	0.35	3.61	0.62
134	May	14	20	0.00	52.31	15.5	0.37	4.72	0.59
134	May	14	21	0.00	17.44	14.0	0.41	3.33	0.57
134	May	14	22	0.00	0.00	11.5	0.49	2.22	0.55
134	May	14	23	0.00	0.00	8.5	0.60	2.50	0.52
134	May	14	24	0.00	0.00	6.0	0.70	2.22	0.49
135	May	15	1	0.00	0.00	6.0	0.76	1.94	0.47
135	May	15	2	0.00	0.00	6.2	0.79	1.94	0.45
135	May	15	3	0.00	0.00	5.8	0.80	2.22	0.42
135	May	15	4	0.00	0.00	7.0	0.74	2.50	0.40
135	May	15	5	0.00	0.00	7.5	0.68	2.78	0.37
135	May	15	6	0.00	0.00	6.0	0.72	3.06	0.35
135	May	15	7	0.00	34.88	6.0	0.76	3.33	0.32
135	May	15	8	0.00	139.50	8.5	0.68	3.61	0.30
135	May	15	9	0.00	279.00	12.5	0.53	3.61	0.27
135	May	15	10	0.00	435.94	16.0	0.40	3.89	0.17
135	May	15	11	0.00	575.44	18.2	0.32	4.17	0.06
135	May	15	12	0.00	662.62	20.0	0.27	4.72	0.03
135	May	15	13	0.00	627.75	20.8	0.24	4.44	0.14
135	May	15	14	0.00	558.00	21.2	0.23	4.44	0.29
135	May	15	15	0.00	383.63	20.8	0.22	3.89	0.51
135	May	15	16	0.00	418.50	21.0	0.22	4.44	0.43
135	May	15	17	0.00	558.00	21.8	0.21	3.89	0.18
135	May	15	18	0.00	366.19	21.0	0.20	3.33	0.22
135	May	15	19	0.00	156.94	20.5	0.21	2.50	0.25
135	May	15	20	0.00	69.75	20.2	0.21	0.28	0.29
135	May	15	21	0.00	34.88	18.8	0.23	0.28	0.33
135	May	15	22	0.00	0.00	15.2	0.32	0.56	0.36
135	May	15	23	0.00	0.00	10.0	0.41	0.28	0.40
135	May	15	24	0.00	0.00	7.5	0.54	0.00	0.44

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
136	May	16	1	0.00	0.00	9.0	0.58	0.83	0.48
136	May	16	2	0.00	0.00	9.2	0.53	1.11	0.51
136	May	16	3	0.00	0.00	7.8	0.65	0.56	0.55
136	May	16	4	0.00	0.00	6.5	0.73	0.28	0.59
136	May	16	5	0.00	0.00	5.5	0.79	0.83	0.62
136	May	16	6	0.00	0.00	5.2	0.82	0.00	0.66
136	May	16	7	0.00	17.44	5.2	0.78	1.39	0.70
136	May	16	8	0.00	52.31	6.2	0.72	1.11	0.73
136	May	16	9	0.00	87.19	9.2	0.60	0.83	0.77
136	May	16	10	0.00	156.94	11.5	0.54	1.94	0.70
136	May	16	11	0.00	244.12	13.8	0.47	2.50	0.60
136	May	16	12	0.00	453.38	15.8	0.49	3.06	0.37
136	May	16	13	0.00	523.12	18.0	0.48	2.78	0.33
136	May	16	14	0.00	523.12	19.5	0.39	2.78	0.35
136	May	16	15	0.00	453.38	19.5	0.36	1.39	0.42
136	May	16	16	0.00	174.38	18.8	0.40	3.33	0.77
136	May	16	17	0.00	34.88	15.2	0.55	6.94	0.95
136	May	16	18	0.80	17.44	11.8	0.78	3.61	0.91
136	May	16	19	0.00	34.88	10.8	0.82	3.61	0.86
136	May	16	20	0.00	34.88	11.0	0.74	2.22	0.82
136	May	16	21	0.00	17.44	10.8	0.78	1.67	0.78
136	May	16	22	0.00	0.00	10.2	0.81	3.06	0.74
136	May	16	23	0.00	0.00	9.8	0.81	1.11	0.69
136	May	16	24	0.00	0.00	9.0	0.84	1.11	0.65
137	May	17	1	0.00	0.00	7.2	0.87	1.94	0.61
137	May	17	2	0.00	0.00	6.0	0.88	1.39	0.57
137	May	17	3	0.00	0.00	5.5	0.89	0.56	0.53
137	May	17	4	0.00	0.00	5.0	0.90	1.11	0.48
137	May	17	5	0.00	0.00	5.0	0.89	2.50	0.44
137	May	17	6	0.00	0.00	6.5	0.89	4.17	0.40
137	May	17	7	0.00	34.88	8.0	0.89	5.28	0.35
137	May	17	8	0.00	104.63	8.0	0.83	6.67	0.31
137	May	17	9	0.00	279.00	9.5	0.73	7.22	0.27
137	May	17	10	0.00	453.37	11.5	0.62	6.67	0.13
137	May	17	11	0.00	418.50	12.2	0.58	4.72	0.31
137	May	17	12	0.00	523.12	12.8	0.56	5.56	0.27
137	May	17	13	0.00	592.88	13.5	0.51	5.56	0.24
137	May	17	14	0.00	592.88	14.5	0.44	4.44	0.26
137	May	17	15	0.00	662.62	15.5	0.40	4.72	0.16
137	May	17	16	0.00	540.56	16.5	0.38	4.72	0.28
137	May	17	17	0.00	418.50	17.0	0.38	4.72	0.38
137	May	17	18	0.00	331.31	17.0	0.36	4.44	0.37
137	May	17	19	0.00	156.94	16.8	0.37	2.78	0.37
137	May	17	20	0.00	34.88	16.2	0.40	2.22	0.36

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
137	May	17	21	0.00	17.44	15.5	0.43	1.67	0.35
137	May	17	22	0.00	0.00	13.5	0.53	0.00	0.35
137	May	17	23	0.00	0.00	10.5	0.62	0.56	0.34
137	May	17	24	0.00	0.00	9.0	0.67	2.22	0.33
138	May	18	1	0.00	0.00	8.0	0.74	1.94	0.33
138	May	18	2	0.00	0.00	6.2	0.83	1.94	0.32
138	May	18	3	0.00	0.00	6.2	0.86	2.78	0.31
138	May	18	4	0.00	0.00	7.0	0.84	3.33	0.30
138	May	18	5	0.00	0.00	7.2	0.82	3.61	0.30
138	May	18	6	0.00	0.00	7.5	0.80	3.89	0.29
138	May	18	7	0.00	34.88	8.0	0.77	3.89	0.28
138	May	18	8	0.00	104.63	9.8	0.72	3.89	0.28
138	May	18	9	0.00	279.00	12.2	0.59	3.89	0.27
138	May	18	10	0.00	313.87	14.2	0.47	3.33	0.40
138	May	18	11	0.00	383.63	16.5	0.44	4.44	0.37
138	May	18	12	0.00	296.44	17.5	0.45	5.83	0.59
138	May	18	13	0.00	122.06	15.8	0.52	5.56	0.84
138	May	18	14	0.00	226.69	14.8	0.47	6.11	0.72
138	May	18	15	0.00	226.69	15.5	0.33	6.39	0.71
138	May	18	16	0.00	244.12	16.0	0.26	5.00	0.67
138	May	18	17	0.00	244.12	15.5	0.34	5.28	0.64
138	May	18	18	0.00	174.38	14.0	0.50	6.67	0.65
138	May	18	19	0.00	104.63	12.2	0.57	6.11	0.66
138	May	18	20	0.00	34.88	11.2	0.62	3.61	0.67
138	May	18	21	0.00	0.00	10.5	0.67	1.94	0.69
138	May	18	22	0.00	0.00	9.5	0.71	2.50	0.70
138	May	18	23	0.00	0.00	9.0	0.68	4.72	0.71
138	May	18	24	0.00	0.00	8.8	0.61	4.44	0.72
139	May	19	1	0.00	0.00	8.0	0.62	4.72	0.73
139	May	19	2	0.00	0.00	7.0	0.70	3.33	0.74
139	May	19	3	0.00	0.00	5.5	0.86	4.17	0.75
139	May	19	4	0.50	0.00	4.0	0.97	4.44	0.76
139	May	19	5	1.00	0.00	2.8	0.97	4.44	0.77
139	May	19	6	1.00	0.00	1.0	0.97	4.72	0.79
139	May	19	7	1.50	0.00	0.8	0.98	4.17	0.80
139	May	19	8	2.00	34.88	0.5	0.96	6.39	0.81
139	May	19	9	2.50	69.75	-0.8	0.95	5.83	0.82
139	May	19	10	1.00	52.31	-1.0	0.95	5.00	0.90
139	May	19	11	1.50	104.62	-0.8	0.93	5.28	0.83
139	May	19	12	0.00	122.06	-0.5	0.91	5.83	0.83
139	May	19	13	0.00	104.63	-0.2	0.92	5.83	0.87
139	May	19	14	0.00	122.06	0.2	0.91	9.17	0.85
139	May	19	15	0.00	104.62	0.8	0.89	10.28	0.87
139	May	19	16	0.00	139.50	1.2	0.86	10.28	0.81
139	May	19	17	0.00	191.81	1.8	0.82	11.11	0.72

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
139	May	19	18	0.00	174.38	2.0	0.78	9.72	0.72
139	May	19	19	0.00	104.63	1.8	0.78	10.28	0.72
139	May	19	20	0.00	34.88	1.2	0.82	8.61	0.72
139	May	19	21	0.00	0.00	1.0	0.86	8.06	0.72
139	May	19	22	0.00	0.00	1.0	0.89	7.50	0.72
139	May	19	23	0.00	0.00	1.0	0.90	7.50	0.72
139	May	19	24	0.00	0.00	1.0	0.88	7.22	0.72
140	May	20	1	0.00	0.00	1.0	0.87	7.50	0.72
140	May	20	2	0.00	0.00	1.2	0.88	7.78	0.73
140	May	20	3	0.00	0.00	1.8	0.88	6.67	0.73
140	May	20	4	0.00	0.00	2.2	0.83	6.67	0.73
140	May	20	5	0.00	0.00	2.2	0.82	5.28	0.73
140	May	20	6	0.00	0.00	2.0	0.84	6.67	0.73
140	May	20	7	0.00	52.31	2.5	0.81	6.94	0.73
140	May	20	8	0.00	87.19	3.5	0.78	8.33	0.73
140	May	20	9	0.00	104.63	5.0	0.71	8.33	0.73
140	May	20	10	0.00	226.69	6.5	0.61	8.89	0.57
140	May	20	11	0.00	261.56	7.5	0.55	10.00	0.57
140	May	20	12	0.00	279.00	8.5	0.50	11.11	0.61
140	May	20	13	0.00	558.00	10.0	0.43	9.17	0.29
140	May	20	14	0.00	662.62	11.5	0.38	9.72	0.17
140	May	20	15	0.00	523.12	11.5	0.38	11.67	0.33
140	May	20	16	0.00	383.63	9.5	0.55	10.56	0.49
140	May	20	17	0.00	244.12	7.5	0.69	9.72	0.64
140	May	20	18	0.00	261.56	7.5	0.61	9.17	0.64
140	May	20	19	0.00	156.94	7.0	0.64	7.22	0.63
140	May	20	20	0.00	34.88	4.8	0.74	7.50	0.63
140	May	20	21	0.00	34.88	3.2	0.81	6.39	0.63
140	May	20	22	0.00	0.00	2.5	0.88	7.50	0.62
140	May	20	23	0.00	0.00	1.5	0.89	5.56	0.62
140	May	20	24	0.00	0.00	1.0	0.89	4.72	0.62
141	May	21	1	0.00	0.00	0.8	0.87	3.61	0.61
141	May	21	2	0.00	0.00	0.8	0.82	3.06	0.61
141	May	21	3	0.00	0.00	0.8	0.81	3.33	0.61
141	May	21	4	0.00	0.00	0.8	0.81	3.33	0.61
141	May	21	5	0.00	0.00	1.0	0.79	4.17	0.60
141	May	21	6	0.00	0.00	1.5	0.78	4.17	0.60
141	May	21	7	0.00	17.44	2.5	0.76	4.17	0.60
141	May	21	8	0.00	69.75	3.5	0.69	5.28	0.59
141	May	21	9	0.00	156.94	4.8	0.62	8.06	0.59
141	May	21	10	0.00	313.87	6.2	0.57	8.61	0.40
141	May	21	11	0.00	453.37	7.5	0.53	8.06	0.26
141	May	21	12	0.00	453.37	8.5	0.48	8.33	0.37
141	May	21	13	0.00	558.00	9.2	0.43	7.78	0.29
141	May	21	14	0.00	662.62	10.0	0.41	7.22	0.17

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
141	May	21	15	0.00	558.00	10.2	0.40	7.78	0.29
141	May	21	16	0.00	592.88	10.0	0.39	6.94	0.21
141	May	21	17	0.00	627.75	9.8	0.39	6.94	0.08
141	May	21	18	0.00	488.25	9.0	0.40	6.67	0.10
141	May	21	19	0.00	348.75	8.2	0.42	6.11	0.12
141	May	21	20	0.00	174.38	7.0	0.47	5.56	0.14
141	May	21	21	0.00	52.31	4.5	0.58	3.89	0.16
141	May	21	22	0.00	17.44	1.5	0.73	2.22	0.18
141	May	21	23	0.00	0.00	0.2	0.84	1.11	0.20
141	May	21	24	0.00	0.00	0.0	0.91	0.56	0.22
142	May	22	1	0.00	0.00	-1.2	0.94	0.56	0.24
142	May	22	2	0.00	0.00	-1.5	0.94	1.11	0.27
142	May	22	3	0.00	0.00	-0.5	0.93	1.39	0.29
142	May	22	4	0.00	0.00	0.2	0.89	1.11	0.31
142	May	22	5	0.00	0.00	1.0	0.86	1.67	0.33
142	May	22	6	0.00	17.44	1.8	0.82	2.22	0.35
142	May	22	7	0.00	87.19	2.2	0.79	2.50	0.37
142	May	22	8	0.00	174.38	3.0	0.73	2.22	0.39
142	May	22	9	0.00	226.69	4.8	0.64	2.78	0.41
142	May	22	10	0.00	331.31	6.2	0.56	3.06	0.37
142	May	22	11	0.00	279.00	6.2	0.56	1.94	0.54
142	May	22	12	0.00	453.38	6.5	0.64	2.22	0.37
142	May	22	13	0.00	470.81	5.5	0.71	2.78	0.40
142	May	22	14	0.00	191.81	4.5	0.71	4.17	0.76
142	May	22	15	0.00	244.12	5.5	0.68	5.28	0.69
142	May	22	16	0.00	279.00	6.0	0.62	4.17	0.63
142	May	22	17	0.00	279.00	5.5	0.58	5.28	0.59
142	May	22	18	0.00	244.12	5.5	0.58	6.11	0.58
142	May	22	19	0.00	244.12	5.5	0.56	6.94	0.56
142	May	22	20	0.00	174.38	4.0	0.56	5.83	0.55
142	May	22	21	0.00	34.88	1.5	0.64	4.44	0.53
142	May	22	22	0.00	0.00	-1.0	0.77	1.94	0.52
142	May	22	23	0.00	0.00	-2.8	0.88	0.28	0.50
142	May	22	24	0.00	0.00	-3.8	0.92	0.28	0.49
143	May	23	1	0.00	0.00	-4.0	0.94	0.56	0.47
143	May	23	2	0.00	0.00	-4.0	0.95	0.56	0.46
143	May	23	3	0.00	0.00	-4.5	0.95	0.00	0.45
143	May	23	4	0.00	0.00	-5.0	0.95	0.28	0.43
143	May	23	5	0.00	0.00	-5.5	0.95	0.56	0.42
143	May	23	6	0.00	17.44	-4.5	0.95	0.28	0.40
143	May	23	7	0.00	52.31	-2.0	0.95	0.00	0.39
143	May	23	8	0.00	104.63	0.8	0.78	0.00	0.37
143	May	23	9	0.00	244.12	2.8	0.61	1.94	0.36
143	May	23	10	0.00	226.69	3.5	0.58	1.67	0.57
143	May	23	11	0.00	174.38	4.0	0.56	2.78	0.71

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
143	May	23	12	0.00	174.38	4.0	0.55	2.22	0.76
143	May	23	13	0.80	87.19	1.8	0.74	2.22	0.89
143	May	23	14	2.00	52.31	-0.8	0.92	2.50	0.93
143	May	23	15	1.00	52.31	-0.8	0.92	2.78	0.93
143	May	23	16	0.00	52.31	-0.2	0.92	2.22	0.93
143	May	23	17	0.00	52.31	0.5	0.92	0.83	0.92
143	May	23	18	0.00	69.75	1.2	0.91	1.11	0.92
143	May	23	19	0.00	69.75	1.5	0.90	3.06	0.92
143	May	23	20	0.00	52.31	1.5	0.89	3.06	0.93
143	May	23	21	0.00	17.44	1.5	0.89	2.78	0.93
143	May	23	22	0.00	0.00	1.5	0.89	3.06	0.93
143	May	23	23	0.00	0.00	1.5	0.89	2.50	0.93
143	May	23	24	0.00	0.00	1.5	0.90	2.22	0.93
144	May	24	1	0.00	0.00	1.5	0.91	2.78	0.94
144	May	24	2	0.00	0.00	1.5	0.92	2.78	0.94
144	May	24	3	0.00	0.00	1.5	0.93	2.22	0.94
144	May	24	4	0.00	0.00	1.5	0.94	2.50	0.94
144	May	24	5	0.00	0.00	1.5	0.94	3.33	0.94
144	May	24	6	0.00	0.00	1.5	0.93	3.61	0.94
144	May	24	7	0.00	17.44	1.5	0.92	4.44	0.95
144	May	24	8	0.00	34.88	1.8	0.91	5.00	0.95
144	May	24	9	0.00	17.44	2.8	0.89	4.72	0.95
144	May	24	10	0.50	17.44	3.2	0.89	5.28	0.97
144	May	24	11	0.50	17.44	3.0	0.90	5.00	0.97
144	May	24	12	0.00	69.75	3.0	0.90	5.28	0.90
144	May	24	13	0.00	87.19	3.0	0.89	6.67	0.89
144	May	24	14	0.00	34.88	3.0	0.88	6.39	0.96
144	May	24	15	0.00	34.88	3.5	0.88	6.39	0.96
144	May	24	16	0.00	52.31	4.0	0.89	7.50	0.93
144	May	24	17	0.00	52.31	4.2	0.88	6.94	0.92
144	May	24	18	0.00	69.75	4.8	0.84	6.67	0.87
144	May	24	19	0.00	122.06	5.0	0.81	6.67	0.83
144	May	24	20	0.00	69.75	5.5	0.79	5.83	0.78
144	May	24	21	0.00	0.00	6.0	0.77	4.17	0.74
144	May	24	22	0.00	0.00	5.5	0.79	3.33	0.69
144	May	24	23	0.00	0.00	5.0	0.80	3.33	0.64
144	May	24	24	0.00	0.00	4.8	0.76	3.33	0.60
145	May	25	1	0.00	0.00	4.5	0.74	3.33	0.55
145	May	25	2	0.00	0.00	4.5	0.76	2.22	0.50
145	May	25	3	0.00	0.00	4.0	0.77	2.22	0.46
145	May	25	4	0.00	0.00	2.8	0.79	1.94	0.41
145	May	25	5	0.00	0.00	2.0	0.81	2.78	0.37
145	May	25	6	0.00	0.00	2.0	0.83	2.22	0.32
145	May	25	7	0.00	17.44	2.2	0.83	2.22	0.27
145	May	25	8	0.00	139.50	2.8	0.80	3.61	0.23

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
145	May	25	9	0.00	313.88	3.5	0.72	4.17	0.18
145	May	25	10	0.00	453.38	5.0	0.62	3.89	0.13
145	May	25	11	0.00	575.44	7.0	0.54	5.00	0.06
145	May	25	12	0.00	697.50	8.5	0.45	5.28	0.02
145	May	25	13	0.00	784.69	9.2	0.40	5.00	0.00
145	May	25	14	0.00	802.12	10.0	0.36	5.00	0.00
145	May	25	15	0.00	784.69	10.8	0.32	4.44	0.00
145	May	25	16	0.00	749.81	11.5	0.27	3.61	0.00
145	May	25	17	0.00	680.06	12.2	0.24	3.06	0.00
145	May	25	18	0.00	558.00	12.8	0.21	1.94	0.02
145	May	25	19	0.00	418.50	13.0	0.18	1.39	0.04
145	May	25	20	0.00	244.12	13.2	0.19	1.67	0.07
145	May	25	21	0.00	87.19	13.2	0.21	0.28	0.09
145	May	25	22	0.00	17.44	10.5	0.33	0.83	0.11
145	May	25	23	0.00	0.00	5.8	0.57	1.11	0.14
145	May	25	24	0.00	0.00	3.0	0.78	1.94	0.16
146	May	26	1	0.00	0.00	2.2	0.85	2.22	0.18
146	May	26	2	0.00	0.00	1.8	0.81	1.94	0.20
146	May	26	3	0.00	0.00	1.2	0.83	1.94	0.22
146	May	26	4	0.00	0.00	0.5	0.89	2.22	0.25
146	May	26	5	0.00	0.00	0.5	0.91	2.50	0.27
146	May	26	6	0.00	0.00	1.0	0.91	2.78	0.29
146	May	26	7	0.00	52.31	1.8	0.90	2.78	0.32
146	May	26	8	0.00	139.50	4.0	0.85	3.61	0.34
146	May	26	9	0.00	244.12	6.8	0.74	3.89	0.36
146	May	26	10	0.00	435.94	9.5	0.61	4.17	0.17
146	May	26	11	0.00	610.31	12.0	0.50	4.44	0.00
146	May	26	12	0.00	732.37	14.0	0.40	3.61	0.00
146	May	26	13	0.00	732.37	15.8	0.33	3.33	0.07
146	May	26	14	0.00	592.88	17.0	0.28	3.33	0.26
146	May	26	15	0.00	488.25	17.8	0.23	4.44	0.38
146	May	26	16	0.00	244.13	17.5	0.23	4.44	0.67
146	May	26	17	0.00	244.13	13.8	0.47	5.83	0.64
146	May	26	18	0.00	383.63	11.2	0.62	3.06	0.64
146	May	26	19	0.00	279.00	13.0	0.49	3.06	0.64
146	May	26	20	0.00	209.25	14.0	0.41	4.72	0.64
146	May	26	21	0.00	104.62	14.0	0.41	1.94	0.64
146	May	26	22	0.00	17.44	11.8	0.48	1.11	0.64
146	May	26	23	0.00	0.00	7.0	0.68	1.39	0.64
146	May	26	24	0.00	0.00	4.0	0.83	1.94	0.64
147	May	27	1	0.00	0.00	3.5	0.89	1.11	0.64
147	May	27	2	0.00	0.00	2.8	0.90	2.78	0.64
147	May	27	3	0.00	0.00	1.8	0.90	2.78	0.64
147	May	27	4	0.00	0.00	2.8	0.89	3.89	0.64
147	May	27	5	0.00	0.00	3.8	0.89	5.56	0.64

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
147	May	27	6	0.00	0.00	3.0	0.91	5.00	0.64
147	May	27	7	0.00	17.44	2.8	0.90	6.11	0.64
147	May	27	8	0.00	69.75	3.2	0.90	6.39	0.64
147	May	27	9	0.00	139.50	3.8	0.88	6.67	0.64
147	May	27	10	0.00	156.94	4.0	0.80	6.67	0.70
147	May	27	11	0.00	191.81	4.0	0.74	5.83	0.69
147	May	27	12	0.00	279.00	4.2	0.70	5.56	0.61
147	May	27	13	0.00	279.00	4.8	0.68	5.28	0.64
147	May	27	14	0.00	401.06	5.0	0.66	5.56	0.50
147	May	27	15	0.00	435.94	5.8	0.59	5.00	0.44
147	May	27	16	0.00	348.75	6.8	0.52	5.28	0.53
147	May	27	17	0.00	505.69	7.8	0.44	5.83	0.26
147	May	27	18	0.00	505.69	9.0	0.33	5.56	0.26
147	May	27	19	0.00	313.88	9.0	0.26	5.28	0.26
147	May	27	20	0.00	209.25	8.2	0.24	5.28	0.26
147	May	27	21	0.00	139.50	8.0	0.27	4.44	0.26
147	May	27	22	0.00	52.31	6.8	0.30	2.22	0.26
147	May	27	23	0.00	0.00	3.8	0.39	1.94	0.26
147	May	27	24	0.00	0.00	1.0	0.51	1.94	0.26
148	May	28	1	0.00	0.00	-0.5	0.60	1.94	0.27
148	May	28	2	0.00	0.00	-2.0	0.68	1.67	0.27
148	May	28	3	0.00	0.00	-4.0	0.76	0.56	0.27
148	May	28	4	0.00	0.00	-5.0	0.84	0.28	0.27
148	May	28	5	0.00	0.00	-5.5	0.88	0.00	0.27
148	May	28	6	0.00	17.44	-5.8	0.90	0.00	0.27
148	May	28	7	0.00	69.75	-4.8	0.91	0.00	0.27
148	May	28	8	0.00	156.94	-2.0	0.82	1.67	0.27
148	May	28	9	0.00	279.00	2.0	0.62	3.06	0.27
148	May	28	10	0.00	435.94	5.0	0.44	2.78	0.17
148	May	28	11	0.00	575.44	6.8	0.34	1.67	0.06
148	May	28	12	0.00	680.06	7.2	0.30	1.39	0.05
148	May	28	13	0.00	749.81	8.2	0.28	1.39	0.04
148	May	28	14	0.00	784.69	10.0	0.26	2.22	0.02
148	May	28	15	0.00	784.69	10.8	0.24	1.67	0.00
148	May	28	16	0.00	714.94	11.5	0.23	1.94	0.05
148	May	28	17	0.00	627.75	12.0	0.23	1.67	0.08
148	May	28	18	0.00	488.25	11.8	0.23	1.39	0.09
148	May	28	19	0.00	348.75	11.2	0.24	1.39	0.10
148	May	28	20	0.00	209.25	10.5	0.26	1.94	0.12
148	May	28	21	0.00	104.62	9.5	0.27	1.11	0.13
148	May	28	22	0.00	52.31	8.2	0.29	2.22	0.14
148	May	28	23	0.00	0.00	5.5	0.36	1.94	0.15
148	May	28	24	0.00	0.00	3.2	0.51	1.67	0.16
149	May	29	1	0.00	0.00	2.5	0.70	2.78	0.17
149	May	29	2	0.00	0.00	1.5	0.83	2.22	0.19

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
149	May	29	3	0.00	0.00	0.8	0.90	2.50	0.20
149	May	29	4	0.00	0.00	0.2	0.92	2.78	0.21
149	May	29	5	0.00	0.00	-0.5	0.92	2.50	0.22
149	May	29	6	0.00	0.00	-1.0	0.91	2.78	0.23
149	May	29	7	0.00	52.31	-1.0	0.92	2.50	0.25
149	May	29	8	0.00	174.38	0.5	0.90	2.78	0.26
149	May	29	9	0.00	279.00	3.0	0.79	3.61	0.27
149	May	29	10	0.00	418.50	5.0	0.68	3.89	0.20
149	May	29	11	0.00	401.06	7.0	0.59	2.78	0.34
149	May	29	12	0.00	331.31	8.0	0.55	3.89	0.54
149	May	29	13	0.00	592.88	8.5	0.54	4.44	0.24
149	May	29	14	0.00	767.25	10.0	0.51	3.33	0.04
149	May	29	15	0.00	732.38	12.0	0.45	3.06	0.07
149	May	29	16	0.00	714.94	13.5	0.39	2.22	0.05
149	May	29	17	0.00	662.62	14.2	0.34	1.11	0.03
149	May	29	18	0.00	505.69	14.8	0.30	1.67	0.07
149	May	29	19	0.00	348.75	15.2	0.27	1.67	0.10
149	May	29	20	0.00	156.94	15.2	0.24	0.56	0.13
149	May	29	21	0.00	52.31	15.0	0.25	0.28	0.17
149	May	29	22	0.00	52.31	13.0	0.30	1.39	0.20
149	May	29	23	0.00	0.00	9.0	0.45	1.94	0.24
149	May	29	24	0.00	0.00	6.0	0.61	1.94	0.27
150	May	30	1	0.00	0.00	5.8	0.71	1.94	0.31
150	May	30	2	0.00	0.00	6.2	0.79	1.94	0.34
150	May	30	3	0.00	0.00	5.5	0.85	1.94	0.38
150	May	30	4	0.00	0.00	4.8	0.89	0.56	0.41
150	May	30	5	0.00	0.00	4.0	0.90	1.67	0.45
150	May	30	6	0.00	0.00	3.8	0.88	4.17	0.48
150	May	30	7	0.00	69.75	4.0	0.86	5.00	0.52
150	May	30	8	0.00	104.63	5.2	0.73	5.00	0.55
150	May	30	9	0.00	156.94	6.8	0.62	4.44	0.59
150	May	30	10	0.00	226.69	7.5	0.63	4.17	0.57
150	May	30	11	0.00	331.31	8.8	0.66	4.17	0.46
150	May	30	12	0.00	313.88	10.2	0.59	3.61	0.56
150	May	30	13	0.00	401.06	11.5	0.43	3.06	0.49
150	May	30	14	0.00	505.69	13.0	0.29	4.44	0.37
150	May	30	15	0.00	610.31	15.0	0.21	3.89	0.22
150	May	30	16	0.00	819.56	16.0	0.17	4.17	0.00
150	May	30	17	0.00	714.94	16.2	0.16	4.17	0.00
150	May	30	18	0.00	575.44	16.5	0.17	3.33	0.02
150	May	30	19	0.00	453.38	16.5	0.20	2.50	0.04
150	May	30	20	0.00	313.88	16.2	0.23	2.78	0.07
150	May	30	21	0.00	156.94	15.8	0.28	1.94	0.09
150	May	30	22	0.00	34.88	15.0	0.35	1.39	0.11
150	May	30	23	0.00	0.00	12.8	0.46	1.39	0.14

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
150	May	30	24	0.00	0.00	8.0	0.55	1.67	0.16
151	May	31	1	0.00	0.00	4.5	0.61	1.39	0.18
151	May	31	2	0.00	0.00	3.8	0.67	1.94	0.20
151	May	31	3	0.00	0.00	2.8	0.67	1.94	0.22
151	May	31	4	0.00	0.00	1.5	0.63	2.22	0.25
151	May	31	5	0.00	0.00	1.0	0.55	2.22	0.27
151	May	31	6	0.00	0.00	1.5	0.47	2.50	0.29
151	May	31	7	0.00	34.88	3.5	0.42	2.78	0.32
151	May	31	8	0.00	122.06	6.0	0.41	3.89	0.34
151	May	31	9	0.00	244.12	9.5	0.38	4.44	0.36
151	May	31	10	0.00	401.06	14.5	0.32	4.17	0.23
151	May	31	11	0.00	558.00	19.8	0.29	4.44	0.09
151	May	31	12	0.00	505.69	22.8	0.29	5.00	0.29
151	May	31	13	0.00	418.50	22.8	0.30	5.28	0.47
151	May	31	14	0.00	627.75	22.0	0.33	4.72	0.22
151	May	31	15	0.00	505.69	22.5	0.36	5.83	0.36
151	May	31	16	0.00	470.81	23.8	0.36	6.39	0.37
151	May	31	17	0.00	453.38	23.5	0.40	5.83	0.33
151	May	31	18	0.00	279.00	23.5	0.46	7.50	0.31
151	May	31	19	0.00	279.00	22.0	0.49	5.56	0.29
151	May	31	20	0.50	104.62	18.5	0.56	2.22	0.27
151	May	31	21	0.00	34.88	16.0	0.69	3.33	0.25
151	May	31	22	0.00	17.44	14.2	0.80	3.06	0.23
151	May	31	23	0.00	0.00	12.5	0.86	1.39	0.21
151	May	31	24	0.00	0.00	11.2	0.90	0.28	0.19
152	June	1	1	0.00	0.00	10.5	0.94	2.50	0.17
152	June	1	2	0.00	0.00	10.5	0.94	3.06	0.14
152	June	1	3	0.00	0.00	11.0	0.93	1.67	0.12
152	June	1	4	0.00	0.00	10.5	0.91	1.94	0.10
152	June	1	5	0.00	17.44	9.8	0.91	1.67	0.08
152	June	1	6	0.00	52.31	9.2	0.93	1.67	0.06
152	June	1	7	0.00	104.63	9.0	0.93	2.50	0.04
152	June	1	8	0.00	226.69	9.5	0.90	5.00	0.02
152	June	1	9	0.50	401.06	11.0	0.83	5.28	0.00
152	June	1	10	0.00	505.69	13.5	0.75	5.56	0.03
152	June	1	11	0.00	488.25	16.0	0.62	6.67	0.22
152	June	1	12	0.00	453.38	17.5	0.54	7.22	0.40
152	June	1	13	0.00	488.25	17.2	0.49	6.67	0.39
152	June	1	14	0.00	401.06	18.0	0.44	6.39	0.50
152	June	1	15	0.00	401.06	19.0	0.40	7.22	0.49
152	June	1	16	0.00	592.88	19.2	0.36	8.33	0.21
152	June	1	17	0.00	523.12	20.2	0.32	7.50	0.23
152	June	1	18	0.00	279.00	20.8	0.28	5.28	0.22
152	June	1	19	0.00	209.25	19.2	0.33	5.28	0.22
152	June	1	20	0.00	174.38	17.2	0.44	3.61	0.21

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
152	June	1	21	0.00	69.75	15.8	0.48	1.67	0.21
152	June	1	22	0.00	17.44	13.8	0.54	0.83	0.20
152	June	1	23	0.00	0.00	10.5	0.67	1.67	0.20
152	June	1	24	0.00	0.00	7.5	0.81	3.61	0.19
153	June	2	1	0.00	0.00	7.0	0.87	1.94	0.18
153	June	2	2	0.00	0.00	8.0	0.83	1.39	0.18
153	June	2	3	0.00	0.00	8.0	0.82	0.56	0.17
153	June	2	4	0.00	0.00	5.8	0.88	1.11	0.17
153	June	2	5	0.00	0.00	4.5	0.92	0.28	0.16
153	June	2	6	0.00	34.88	4.2	0.93	0.28	0.16
153	June	2	7	0.00	87.19	4.5	0.93	0.00	0.15
153	June	2	8	0.00	174.38	6.0	0.89	0.28	0.15
153	June	2	9	0.00	331.31	9.0	0.77	0.56	0.14
153	June	2	10	0.00	488.25	13.0	0.59	2.22	0.07
153	June	2	11	0.00	645.19	16.5	0.45	3.33	0.00
153	June	2	12	0.00	453.38	19.0	0.38	2.78	0.40
153	June	2	13	0.00	523.12	20.5	0.34	4.44	0.35
153	June	2	14	0.00	627.75	20.0	0.32	5.28	0.22
153	June	2	15	0.00	418.50	19.8	0.29	4.72	0.47
153	June	2	16	0.00	558.00	21.2	0.26	7.22	0.26
153	June	2	17	0.00	470.81	21.5	0.23	5.83	0.31
153	June	2	18	0.00	313.88	19.8	0.28	3.89	0.29
153	June	2	19	0.00	296.44	18.5	0.33	5.28	0.27
153	June	2	20	0.00	139.50	15.2	0.51	2.22	0.25
153	June	2	21	0.00	34.88	11.8	0.75	3.61	0.23
153	June	2	22	0.00	17.44	10.8	0.82	2.22	0.21
153	June	2	23	0.00	0.00	10.0	0.85	1.94	0.19
153	June	2	24	0.00	0.00	10.0	0.85	1.94	0.17
154	June	3	1	0.00	0.00	10.0	0.85	2.22	0.15
154	June	3	2	0.00	0.00	10.0	0.85	2.50	0.14
154	June	3	3	0.00	0.00	10.0	0.86	3.33	0.12
154	June	3	4	0.00	0.00	9.5	0.89	2.78	0.10
154	June	3	5	0.00	0.00	8.5	0.91	2.50	0.08
154	June	3	6	0.00	52.31	7.5	0.92	2.50	0.06
154	June	3	7	0.00	156.94	7.2	0.93	3.33	0.04
154	June	3	8	0.00	296.44	8.2	0.90	4.44	0.02
154	June	3	9	0.00	488.25	10.0	0.82	3.61	0.00
154	June	3	10	0.00	645.19	11.8	0.71	3.06	0.00
154	June	3	11	0.00	749.81	13.8	0.59	4.17	0.00
154	June	3	12	0.00	558.00	15.8	0.47	5.28	0.26
154	June	3	13	0.00	558.00	16.8	0.37	5.00	0.30
154	June	3	14	0.00	523.12	17.5	0.39	5.56	0.35
154	June	3	15	0.00	488.25	18.2	0.40	5.00	0.38
154	June	3	16	0.00	592.88	19.2	0.36	5.28	0.21
154	June	3	17	0.00	488.25	19.8	0.33	5.28	0.28

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
154	June	3	18	0.00	435.94	19.8	0.31	4.44	0.27
154	June	3	19	0.00	296.44	19.8	0.29	4.17	0.26
154	June	3	20	0.00	156.94	19.2	0.29	4.44	0.24
154	June	3	21	0.00	52.31	18.2	0.30	2.78	0.23
154	June	3	22	0.00	17.44	16.2	0.35	0.56	0.22
154	June	3	23	0.00	0.00	13.0	0.47	0.56	0.21
154	June	3	24	0.00	0.00	10.5	0.59	1.67	0.20
155	June	4	1	0.00	0.00	9.5	0.69	1.67	0.18
155	June	4	2	0.00	0.00	8.5	0.77	1.67	0.17
155	June	4	3	0.00	0.00	8.0	0.81	1.94	0.16
155	June	4	4	0.00	0.00	8.2	0.80	1.94	0.15
155	June	4	5	0.00	0.00	8.8	0.77	1.94	0.14
155	June	4	6	0.00	17.44	9.5	0.73	1.94	0.13
155	June	4	7	0.00	104.62	10.2	0.73	1.94	0.11
155	June	4	8	0.00	209.25	11.2	0.72	1.39	0.10
155	June	4	9	0.00	348.75	13.0	0.64	1.94	0.09
155	June	4	10	0.00	540.56	15.5	0.55	1.94	0.00
155	June	4	11	0.00	610.31	19.2	0.45	1.94	0.03
155	June	4	12	0.00	697.50	22.0	0.35	2.22	0.07
155	June	4	13	0.00	662.62	22.2	0.30	3.06	0.17
155	June	4	14	0.00	627.75	22.5	0.28	3.61	0.22
155	June	4	15	0.00	714.94	23.0	0.28	2.78	0.09
155	June	4	16	0.00	662.62	23.2	0.28	2.22	0.12
155	June	4	17	0.00	592.88	23.2	0.27	1.94	0.13
155	June	4	18	0.00	366.19	23.0	0.25	2.50	0.12
155	June	4	19	0.00	261.56	23.0	0.23	2.78	0.11
155	June	4	20	0.00	226.69	23.0	0.23	1.67	0.11
155	June	4	21	0.00	69.75	22.2	0.24	0.56	0.10
155	June	4	22	0.00	17.44	19.2	0.30	1.11	0.09
155	June	4	23	0.00	0.00	16.0	0.41	1.39	0.08
155	June	4	24	0.00	0.00	14.5	0.47	1.94	0.07
156	June	5	1	0.00	0.00	13.0	0.53	1.94	0.07
156	June	5	2	0.00	0.00	11.8	0.58	1.94	0.06
156	June	5	3	0.00	0.00	11.5	0.62	2.22	0.05
156	June	5	4	0.00	0.00	11.2	0.65	2.78	0.04
156	June	5	5	0.00	17.44	10.8	0.68	2.50	0.03
156	June	5	6	0.00	87.19	10.2	0.70	2.22	0.02
156	June	5	7	0.00	156.94	10.2	0.70	1.94	0.02
156	June	5	8	0.00	296.44	11.0	0.70	1.94	0.01
156	June	5	9	0.00	470.81	12.8	0.66	1.39	0.00
156	June	5	10	0.00	592.88	16.0	0.57	0.83	0.00
156	June	5	11	0.00	680.06	20.5	0.47	0.56	0.00
156	June	5	12	0.00	714.94	24.5	0.35	1.39	0.05
156	June	5	13	0.00	732.38	26.8	0.26	1.67	0.09
156	June	5	14	0.00	592.88	28.0	0.22	2.78	0.26

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
156	June	5	15	0.00	575.44	28.8	0.18	4.72	0.27
156	June	5	16	0.00	575.44	29.2	0.17	4.44	0.23
156	June	5	17	0.00	488.25	29.5	0.16	4.44	0.28
156	June	5	18	0.00	383.63	29.2	0.15	3.89	0.27
156	June	5	19	0.00	244.12	29.0	0.15	4.17	0.26
156	June	5	20	0.00	174.38	28.0	0.15	3.06	0.25
156	June	5	21	0.00	69.75	26.5	0.17	5.56	0.25
156	June	5	22	0.00	17.44	24.8	0.23	7.22	0.24
156	June	5	23	0.00	0.00	21.8	0.32	5.56	0.23
156	June	5	24	0.00	0.00	19.0	0.44	3.06	0.22
157	June	6	1	0.00	0.00	16.5	0.67	4.44	0.21
157	June	6	2	0.00	0.00	14.2	0.86	3.89	0.20
157	June	6	3	0.00	0.00	13.0	0.89	1.67	0.19
157	June	6	4	0.00	0.00	11.5	0.91	0.56	0.18
157	June	6	5	0.00	17.44	9.2	0.95	2.50	0.18
157	June	6	6	0.00	104.62	9.0	0.93	2.50	0.17
157	June	6	7	0.00	279.00	11.2	0.82	5.00	0.16
157	June	6	8	0.00	470.81	12.2	0.78	2.50	0.15
157	June	6	9	0.00	331.31	13.0	0.75	2.22	0.14
157	June	6	10	0.00	261.56	15.0	0.65	3.61	0.50
157	June	6	11	0.00	296.44	17.0	0.54	5.28	0.53
157	June	6	12	0.00	261.56	16.8	0.54	5.00	0.65
157	June	6	13	0.00	505.69	15.0	0.65	4.17	0.37
157	June	6	14	0.00	697.50	15.0	0.62	5.28	0.13
157	June	6	15	0.00	697.50	16.5	0.51	3.61	0.11
157	June	6	16	0.00	627.75	18.2	0.48	7.22	0.16
157	June	6	17	0.00	348.75	20.0	0.40	8.61	0.49
157	June	6	18	0.00	261.56	19.5	0.39	8.89	0.48
157	June	6	19	0.00	313.87	18.5	0.45	7.78	0.47
157	June	6	20	0.00	156.94	18.2	0.43	7.50	0.47
157	June	6	21	0.00	52.31	16.8	0.46	5.56	0.46
157	June	6	22	0.00	0.00	15.0	0.52	4.17	0.45
157	June	6	23	0.00	0.00	12.5	0.62	3.61	0.44
157	June	6	24	0.00	0.00	10.5	0.74	3.06	0.43
158	June	7	1	0.00	0.00	10.0	0.81	2.50	0.42
158	June	7	2	0.00	0.00	10.0	0.84	3.89	0.42
158	June	7	3	0.00	0.00	10.0	0.86	3.61	0.41
158	June	7	4	0.00	0.00	10.5	0.79	2.50	0.40
158	June	7	5	0.00	34.88	11.5	0.78	3.06	0.39
158	June	7	6	0.00	139.50	12.5	0.82	2.78	0.38
158	June	7	7	0.00	191.81	14.0	0.75	2.50	0.38
158	June	7	8	0.00	174.38	16.0	0.66	3.06	0.37
158	June	7	9	0.00	244.12	17.8	0.62	3.33	0.36
158	June	7	10	0.00	348.75	19.2	0.58	3.06	0.33
158	June	7	11	0.00	592.88	20.8	0.57	3.89	0.06

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
158	June	7	12	0.00	488.25	22.0	0.57	3.33	0.35
158	June	7	13	0.00	313.88	22.8	0.52	3.33	0.61
158	June	7	14	0.00	627.75	22.8	0.45	3.89	0.22
158	June	7	15	0.00	662.62	22.0	0.43	2.78	0.16
158	June	7	16	0.00	383.63	22.5	0.43	2.50	0.49
158	June	7	17	0.00	209.25	22.5	0.41	1.94	0.69
158	June	7	18	0.00	313.88	22.2	0.38	2.50	0.69
158	June	7	19	0.00	313.88	23.2	0.38	2.22	0.70
158	June	7	20	0.00	122.06	21.8	0.48	2.50	0.70
158	June	7	21	0.00	52.31	18.5	0.65	2.50	0.71
158	June	7	22	0.00	17.44	15.8	0.81	1.67	0.71
158	June	7	23	0.00	0.00	14.0	0.90	1.94	0.72
158	June	7	24	0.00	0.00	12.2	0.94	1.67	0.72
159	June	8	1	0.00	0.00	11.2	0.96	1.94	0.73
159	June	8	2	0.00	0.00	10.8	0.97	1.67	0.73
159	June	8	3	0.00	0.00	10.5	0.98	1.67	0.74
159	June	8	4	0.00	0.00	11.0	0.99	1.67	0.74
159	June	8	5	0.00	0.00	10.8	0.99	1.39	0.75
159	June	8	6	0.00	17.44	10.0	0.99	0.83	0.76
159	June	8	7	0.00	52.31	9.5	0.99	1.94	0.76
159	June	8	8	0.00	87.19	10.2	0.96	0.56	0.77
159	June	8	9	0.00	87.19	11.5	0.89	1.94	0.77
159	June	8	10	0.00	87.19	12.2	0.81	1.67	0.83
159	June	8	11	0.00	104.62	13.5	0.79	3.06	0.83
159	June	8	12	0.00	122.06	14.2	0.81	2.50	0.84
159	June	8	13	0.00	139.50	15.0	0.74	2.78	0.83
159	June	8	14	0.00	313.87	17.0	0.57	3.61	0.61
159	June	8	15	0.00	418.50	18.8	0.45	3.61	0.47
159	June	8	16	0.00	592.88	20.5	0.38	3.61	0.21
159	June	8	17	0.00	627.75	21.5	0.33	3.89	0.08
159	June	8	18	0.00	523.12	21.8	0.31	4.17	0.13
159	June	8	19	0.00	592.88	21.5	0.31	3.33	0.18
159	June	8	20	0.00	418.50	20.2	0.34	3.61	0.23
159	June	8	21	0.00	191.81	18.8	0.39	2.22	0.28
159	June	8	22	0.00	52.31	16.5	0.55	1.39	0.32
159	June	8	23	0.00	0.00	14.0	0.76	1.67	0.37
159	June	8	24	0.00	0.00	13.0	0.83	2.22	0.42
160	June	9	1	0.00	0.00	13.0	0.78	3.33	0.47
160	June	9	2	0.00	0.00	13.0	0.70	3.33	0.52
160	June	9	3	0.00	0.00	13.0	0.69	3.33	0.57
160	June	9	4	3.50	0.00	12.2	0.71	4.72	0.62
160	June	9	5	0.00	0.00	11.2	0.81	4.44	0.66
160	June	9	6	1.50	0.00	11.0	0.89	3.61	0.71
160	June	9	7	1.50	17.44	10.5	0.87	4.72	0.76
160	June	9	8	1.00	34.88	10.0	0.88	3.61	0.81

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
160	June	9	9	1.50	52.31	10.0	0.88	5.28	0.86
160	June	9	10	0.00	69.75	10.2	0.88	5.56	0.87
160	June	9	11	2.00	139.50	10.5	0.88	5.28	0.78
160	June	9	12	0.00	383.63	11.0	0.87	4.72	0.49
160	June	9	13	0.00	313.88	12.8	0.83	5.56	0.61
160	June	9	14	1.50	104.63	15.0	0.73	5.83	0.87
160	June	9	15	0.50	104.63	15.0	0.74	6.67	0.87
160	June	9	16	2.50	279.00	14.5	0.78	5.83	0.63
160	June	9	17	0.00	383.63	15.8	0.76	5.00	0.44
160	June	9	18	0.00	174.38	15.8	0.77	5.56	0.45
160	June	9	19	4.50	209.25	14.2	0.80	5.56	0.45
160	June	9	20	0.00	226.69	14.0	0.84	4.72	0.46
160	June	9	21	0.00	52.31	14.8	0.82	2.22	0.47
160	June	9	22	0.00	0.00	14.5	0.84	1.67	0.47
160	June	9	23	0.00	0.00	13.5	0.88	2.78	0.48
160	June	9	24	0.00	0.00	12.5	0.89	2.78	0.49
161	June	10	1	0.00	0.00	11.2	0.88	2.78	0.49
161	June	10	2	0.00	0.00	10.2	0.86	2.22	0.50
161	June	10	3	0.00	0.00	9.2	0.86	1.94	0.51
161	June	10	4	0.00	0.00	8.8	0.88	1.39	0.52
161	June	10	5	0.00	0.00	8.5	0.89	1.94	0.52
161	June	10	6	0.00	17.44	8.0	0.89	1.67	0.53
161	June	10	7	0.00	52.31	8.5	0.89	1.94	0.54
161	June	10	8	0.00	104.63	9.2	0.89	2.22	0.54
161	June	10	9	0.00	174.38	9.8	0.88	3.89	0.55
161	June	10	10	0.00	261.56	10.5	0.85	4.17	0.50
161	June	10	11	0.00	348.75	11.2	0.83	4.17	0.44
161	June	10	12	0.00	488.25	11.8	0.80	5.56	0.35
161	June	10	13	0.00	435.94	13.2	0.74	5.83	0.46
161	June	10	14	0.00	383.63	14.8	0.67	5.28	0.52
161	June	10	15	0.00	575.44	15.2	0.66	5.83	0.27
161	June	10	16	0.00	488.25	16.2	0.65	5.83	0.35
161	June	10	17	0.00	435.94	17.0	0.61	6.39	0.36
161	June	10	18	0.00	435.94	17.5	0.61	5.56	0.37
161	June	10	19	0.00	226.69	17.5	0.61	4.72	0.38
161	June	10	20	0.00	139.50	16.2	0.62	4.72	0.39
161	June	10	21	0.00	87.19	15.2	0.64	4.44	0.40
161	June	10	22	5.50	17.44	13.8	0.77	3.33	0.40
161	June	10	23	0.00	0.00	12.0	0.87	2.78	0.41
161	June	10	24	0.00	0.00	11.2	0.86	1.39	0.42
162	June	11	1	0.00	0.00	11.0	0.87	1.11	0.43
162	June	11	2	0.00	0.00	10.8	0.88	2.22	0.44
162	June	11	3	0.00	0.00	10.5	0.88	2.22	0.45
162	June	11	4	0.00	0.00	10.2	0.88	1.11	0.46
162	June	11	5	0.00	0.00	9.8	0.88	1.94	0.46

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
162	June	11	6	0.00	17.44	9.0	0.88	2.78	0.47
162	June	11	7	0.00	87.19	8.5	0.88	3.06	0.48
162	June	11	8	0.00	139.50	8.8	0.88	3.61	0.49
162	June	11	9	0.00	191.81	9.2	0.88	3.89	0.50
162	June	11	10	0.00	418.50	10.0	0.84	4.17	0.20
162	June	11	11	0.00	610.31	11.5	0.79	3.61	0.03
162	June	11	12	0.00	662.62	13.5	0.74	4.72	0.12
162	June	11	13	0.00	697.50	15.2	0.67	5.56	0.13
162	June	11	14	0.00	680.06	16.5	0.64	6.67	0.15
162	June	11	15	0.00	680.06	17.5	0.60	6.67	0.13
162	June	11	16	0.00	662.62	18.5	0.51	5.56	0.12
162	June	11	17	0.00	592.88	19.2	0.43	5.28	0.13
162	June	11	18	0.00	453.38	19.5	0.40	5.00	0.13
162	June	11	19	0.00	331.31	19.5	0.39	4.17	0.14
162	June	11	20	0.00	226.69	19.2	0.38	2.78	0.14
162	June	11	21	0.00	104.63	18.8	0.37	1.11	0.14
162	June	11	22	0.00	34.88	17.8	0.40	0.28	0.15
162	June	11	23	0.00	0.00	15.5	0.51	0.83	0.15
162	June	11	24	0.00	0.00	13.0	0.68	1.11	0.15
163	June	12	1	0.00	0.00	6.2	0.80	1.67	0.15
163	June	12	2	0.00	0.00	4.8	0.86	1.39	0.16
163	June	12	3	0.00	0.00	8.0	0.89	1.39	0.16
163	June	12	4	0.00	0.00	6.8	0.90	0.83	0.16
163	June	12	5	0.00	0.00	6.2	0.90	1.39	0.17
163	June	12	6	0.00	17.44	5.5	0.90	1.39	0.17
163	June	12	7	0.00	69.75	5.2	0.90	1.67	0.17
163	June	12	8	0.00	174.38	6.5	0.90	2.50	0.18
163	June	12	9	0.00	313.88	9.8	0.82	3.61	0.18
163	June	12	10	0.00	453.38	13.0	0.68	3.89	0.13
163	June	12	11	0.00	558.00	15.2	0.56	2.22	0.11
163	June	12	12	0.00	610.31	17.2	0.47	1.94	0.19
163	June	12	13	0.00	645.19	18.5	0.41	1.67	0.20
163	June	12	14	0.00	680.06	19.5	0.39	3.06	0.15
163	June	12	15	0.00	662.62	20.2	0.33	2.78	0.16
163	June	12	16	0.00	592.88	20.8	0.29	3.06	0.21
163	June	12	17	0.00	540.56	21.0	0.28	2.78	0.21
163	June	12	18	0.00	488.25	21.0	0.27	2.78	0.21
163	June	12	19	0.00	401.06	21.0	0.25	2.78	0.21
163	June	12	20	0.00	244.12	21.0	0.25	3.89	0.20
163	June	12	21	0.00	104.63	20.5	0.27	3.89	0.20
163	June	12	22	0.00	34.88	19.2	0.29	2.78	0.20
163	June	12	23	0.00	0.00	16.8	0.34	2.50	0.20
163	June	12	24	0.00	0.00	14.2	0.43	2.78	0.20
164	June	13	1	0.00	0.00	12.8	0.52	3.61	0.20
164	June	13	2	0.00	0.00	11.5	0.54	3.89	0.19

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
164	June	13	3	0.00	0.00	10.5	0.54	3.33	0.19
164	June	13	4	0.00	0.00	10.2	0.60	3.61	0.19
164	June	13	5	0.00	0.00	10.2	0.66	3.61	0.19
164	June	13	6	0.00	6.98	9.5	0.73	3.33	0.19
164	June	13	7	0.00	41.85	9.2	0.78	3.89	0.18
164	June	13	8	0.00	139.50	9.8	0.73	6.39	0.18
164	June	13	9	0.00	313.87	10.5	0.69	6.67	0.18
164	June	13	10	0.00	488.25	12.0	0.64	7.22	0.07
164	June	13	11	0.00	627.75	13.8	0.56	7.78	0.00
164	June	13	12	0.00	739.35	15.2	0.48	6.67	0.01
164	June	13	13	0.00	781.20	17.0	0.42	7.50	0.03
164	June	13	14	0.00	774.23	18.8	0.35	8.06	0.03
164	June	13	15	0.00	767.25	20.0	0.30	7.78	0.02
164	June	13	16	0.00	732.38	21.0	0.25	7.78	0.02
164	June	13	17	0.00	645.19	21.8	0.22	8.33	0.05
164	June	13	18	0.00	558.00	22.0	0.21	7.78	0.05
164	June	13	19	0.00	435.94	22.0	0.21	7.22	0.05
164	June	13	20	0.00	296.44	21.8	0.23	7.78	0.05
164	June	13	21	0.00	191.81	21.2	0.25	6.94	0.05
164	June	13	22	0.00	69.75	20.5	0.26	5.28	0.05
164	June	13	23	0.00	0.00	18.5	0.29	4.72	0.05
164	June	13	24	0.00	0.00	16.2	0.36	5.56	0.05
165	June	14	1	0.00	0.00	15.2	0.48	5.56	0.05
165	June	14	2	0.00	0.00	14.5	0.54	5.56	0.05
165	June	14	3	0.00	0.00	13.5	0.55	6.11	0.05
165	June	14	4	0.00	0.00	12.8	0.59	4.44	0.05
165	June	14	5	0.00	0.00	12.5	0.63	6.11	0.05
165	June	14	6	0.00	34.88	12.0	0.66	5.56	0.05
165	June	14	7	0.00	104.63	11.2	0.70	6.11	0.05
165	June	14	8	0.00	209.25	11.2	0.74	7.50	0.05
165	June	14	9	0.00	366.19	11.8	0.73	8.06	0.05
165	June	14	10	0.00	540.56	12.5	0.70	8.06	0.00
165	June	14	11	0.00	470.81	14.5	0.66	8.33	0.25
165	June	14	12	0.00	313.88	16.8	0.57	8.89	0.58
165	June	14	13	0.00	296.44	18.5	0.51	8.61	0.63
165	June	14	14	0.00	523.12	19.2	0.47	7.22	0.35
165	June	14	15	0.00	558.00	19.5	0.47	5.83	0.29
165	June	14	16	0.00	488.25	21.2	0.47	4.72	0.35
165	June	14	17	0.00	418.50	22.8	0.45	5.56	0.38
165	June	14	18	0.00	313.87	24.0	0.43	6.11	0.39
165	June	14	19	0.00	313.87	24.5	0.42	5.28	0.41
165	June	14	20	0.00	156.94	24.8	0.42	1.94	0.42
165	June	14	21	0.00	69.75	25.5	0.42	2.50	0.43
165	June	14	22	0.00	17.44	25.2	0.39	2.50	0.45
165	June	14	23	0.00	0.00	24.0	0.38	3.06	0.46

Table A5.1 Hourly meteorological observations for the Lunty site

Day Num	Month	Day	Hr	Prec (mm)	Global Radiation (W m-2)	Mean Air Temperature (degrees C)	Relative Humidity (fraction)	Wind Speed (m/sec)	Cloud Cover (fraction)
165	June	14	24	0.00	0.00	22.5	0.37	5.28	0.47
166	June	15	1	0.00	0.00	18.5	0.46	3.89	0.48
166	June	15	2	0.00	0.00	12.5	0.73	2.22	0.50
166	June	15	3	0.00	0.00	9.5	0.90	1.67	0.51
166	June	15	4	0.00	0.00	9.0	0.90	2.22	0.52
166	June	15	5	0.00	0.00	9.0	0.90	1.67	0.54
166	June	15	6	0.00	0.00	9.5	0.89	1.11	0.55
166	June	15	7	1.50	17.44	11.0	0.85	1.94	0.56
166	June	15	8	0.00	69.75	12.5	0.78	1.94	0.58
166	June	15	9	0.00	156.94	14.0	0.68	2.22	0.59
166	June	15	10	2.00	313.87	16.2	0.59	2.22	0.40
166	June	15	11	1.50	348.75	18.2	0.55	2.78	0.44
166	June	15	12	0.00	348.75	19.2	0.52	3.61	0.53
166	June	15	13	0.50	470.81	20.0	0.51	3.33	0.41
166	June	15	14	0.00	610.31	20.8	0.51	4.17	0.24

Table A5.2 Daily rainfall recorded at the Lunty site from April 7 to Oct 30, 1989.

Julian Day No.	Date	Rainfall (mm)
97	April 7	4.0
111	April 21	0.5
112	April 22	2.5
122	May 2	1.0
123	May 3	0.8
127	May 7	0.5
136	May 16	0.8
139	May 19	11.0
143	May 23	3.8
144	May 24	1.0
151	May 31	0.5
152	June 1	0.5
160	June 9	20.0
161	June 10	5.5
166	June 15	5.5
167	June 16	0.5
172	June 21	3.0
175	June 24	16.0
178	June 27	14.0
180	June 29	10.5
181	June 30	16.5
185	July 4	10.0
189	July 8	2.0
192	July 11	36.0
198	July 17	2.0
201	July 20	4.0
208	July 27	15.0
215	Aug 3	3.0
228	Aug 16	15.0
232	Aug 20	14.0
241	Aug 29	17.0
242	Aug 30	8.5
245	Sept 2	3.0
248	Sept 5	13.0
262	Sept 19	1.0
289	Oct 15	15.0
304	Oct 30	7.0

Table A5.3 Original and rainfall corrected pan evaporation data for the Lunty site for April to October, 1989.

Julian Day No.	Date of Pan Reading		Pan Reading (mm)	New Rainfall (mm)	Net Pan Evaporation (mm)	Cumulative Evaporation (mm)	Cumulative Rainfall (mm)
90	March	31	0.0	0.0	0.0	0.0	0.0
95	April	5	8.0	0.0	8.0	8.0	0.0
103	April	13	13.2	4.0	17.2	25.2	4.0
110	April	20	27..8	0.0	27.8	53.0	4.0
117	April	27	17.8	3.0	20.8	73.8	7.0
123	May	3	26.8	1.8	28.6	102.4	8.8
130	May	10	48.8	0.5	49.3	151.7	9.3
135	May	15	38.4	0.0	38.4	190.1	9.3
137	May	17	6.1	0.8	6.9	197.0	10.1
144	May	24	3.6	15.8	19.4	216.4	25.9
151	May	31	30.4	0.5	30.9	247.3	26.4
157	June	6	42.9	0.5	43.4	290.7	26.9
166	June	15	33.2	25.5	58.7	349.4	52.4
172	June	21	17.5	9.0	26.5	375.9	61.4
180	June	29	29.1	30.5	59.6	435.5	91.9
186	July	5	8.7	26.5	35.2	470.7	118.4
193	July	12	-3.0	38.0	35.0	505.7	156.4
201	July	20	40.2	6.0	46.2	551.9	162.4
205	July	24	29.5	0.0	29.5	581.4	162.4
208	July	27	31.1	0.0	31.1	612.5	162.4
215	Aug	3	18.0	15.0	33.0	645.5	177.4
220	Aug	8	14.4	3.0	17.4	662.9	180.4
228	Aug	16	45.4	0.0	45.4	708.3	180.4
236	Aug	24	-11.5	29.0	17.5	725.8	209.4
242	Aug	30	-19.6	25.5	5.9	731.7	234.9
250	Sept	7	-0.1	16.0	15.9	747.6	250.9
255	Sept	12	14.5	0.0	14.5	762.1	250.9
262	Sept	19	14.8	1.0	15.8	777.9	251.9
270	Sept	27	22.2	0.0	22.2	800.1	251.9
287	Oct	13	35.0	0.0	35.0	835.1	251.9
291	Oct	17	-7.0	15.0	8.0	843.1	266.9
304	Oct	30	10.4	7.0	17.4	860.5	273.9

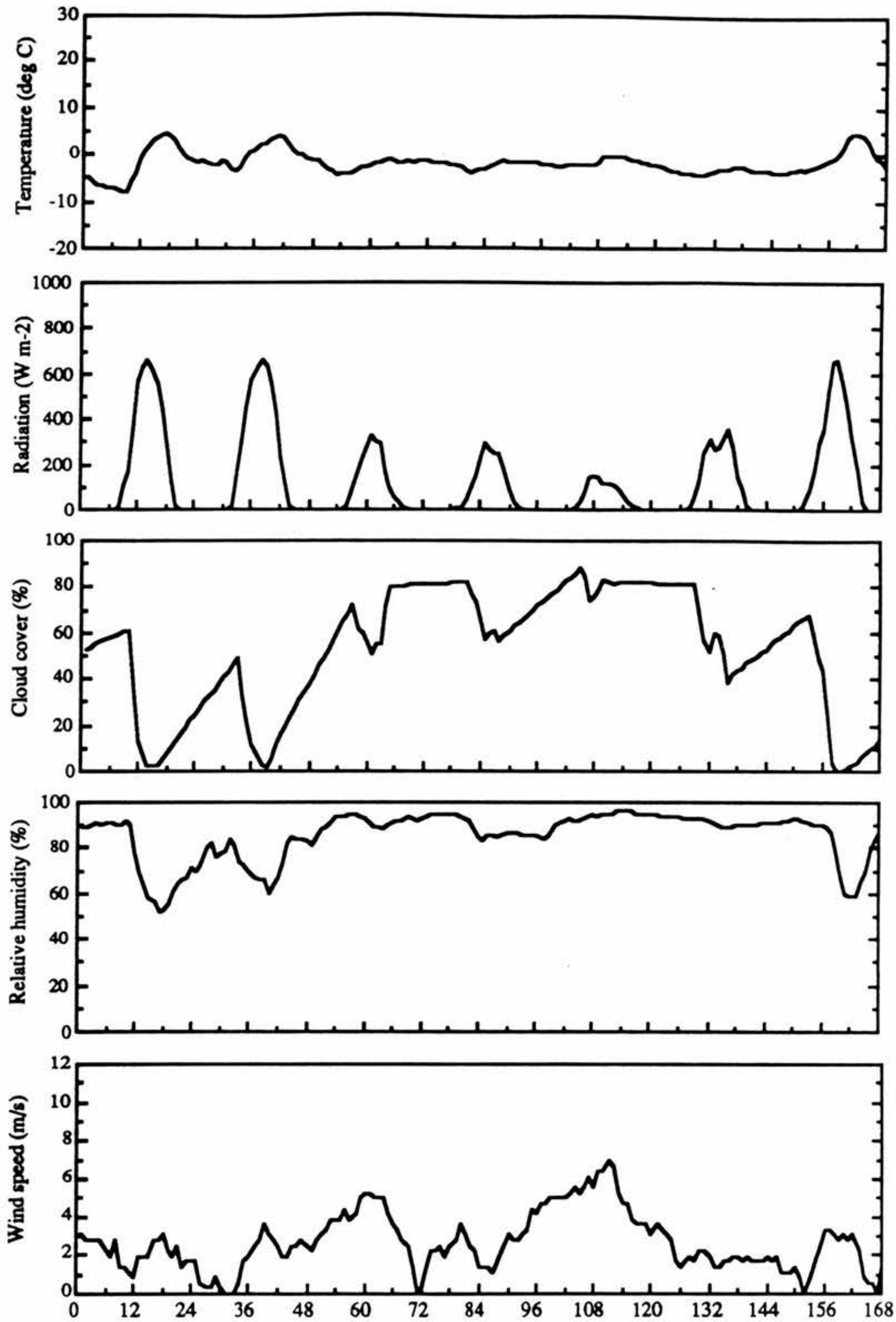


Figure A5.1 Hourly meteorological data at the Lunty site for week 1 (March 23-29, 1989)

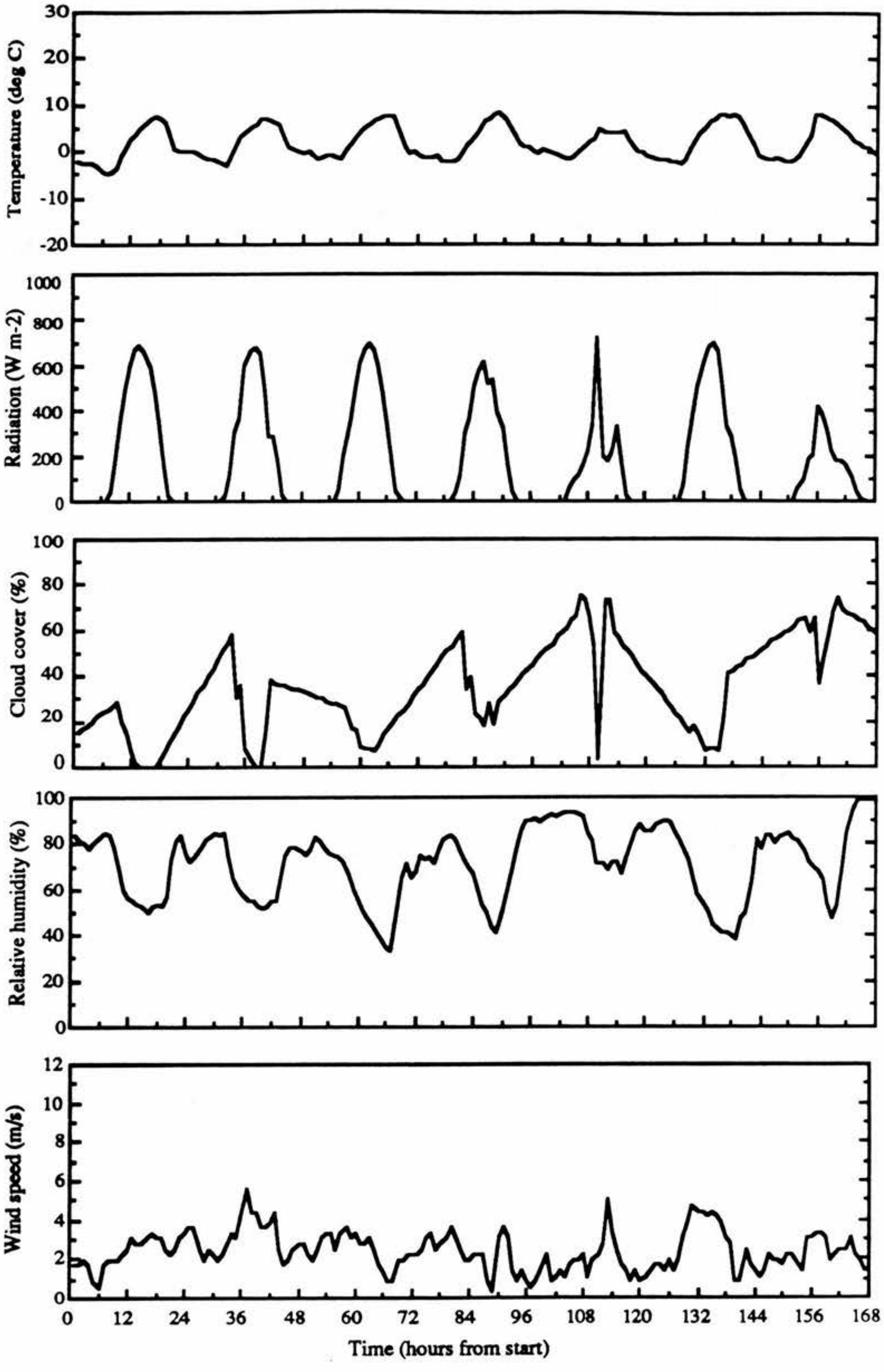


Figure A5.2 Hourly meteorological data at the Lunty site for week 2 (March 30 - April 5, 1989)

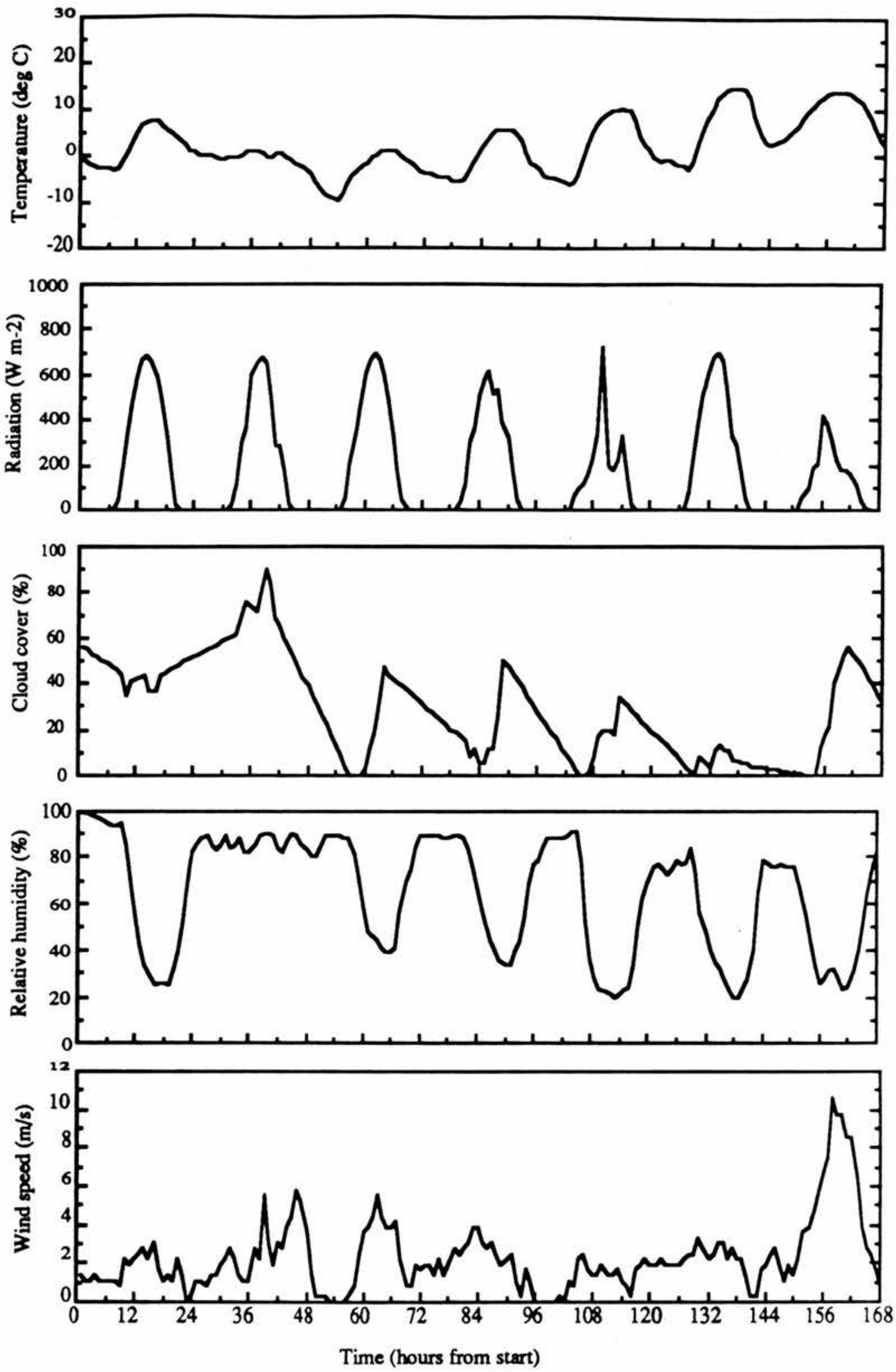


Figure A5.3 Hourly meteorological data at the Lunty site for week 3 (April 6-12, 1989)

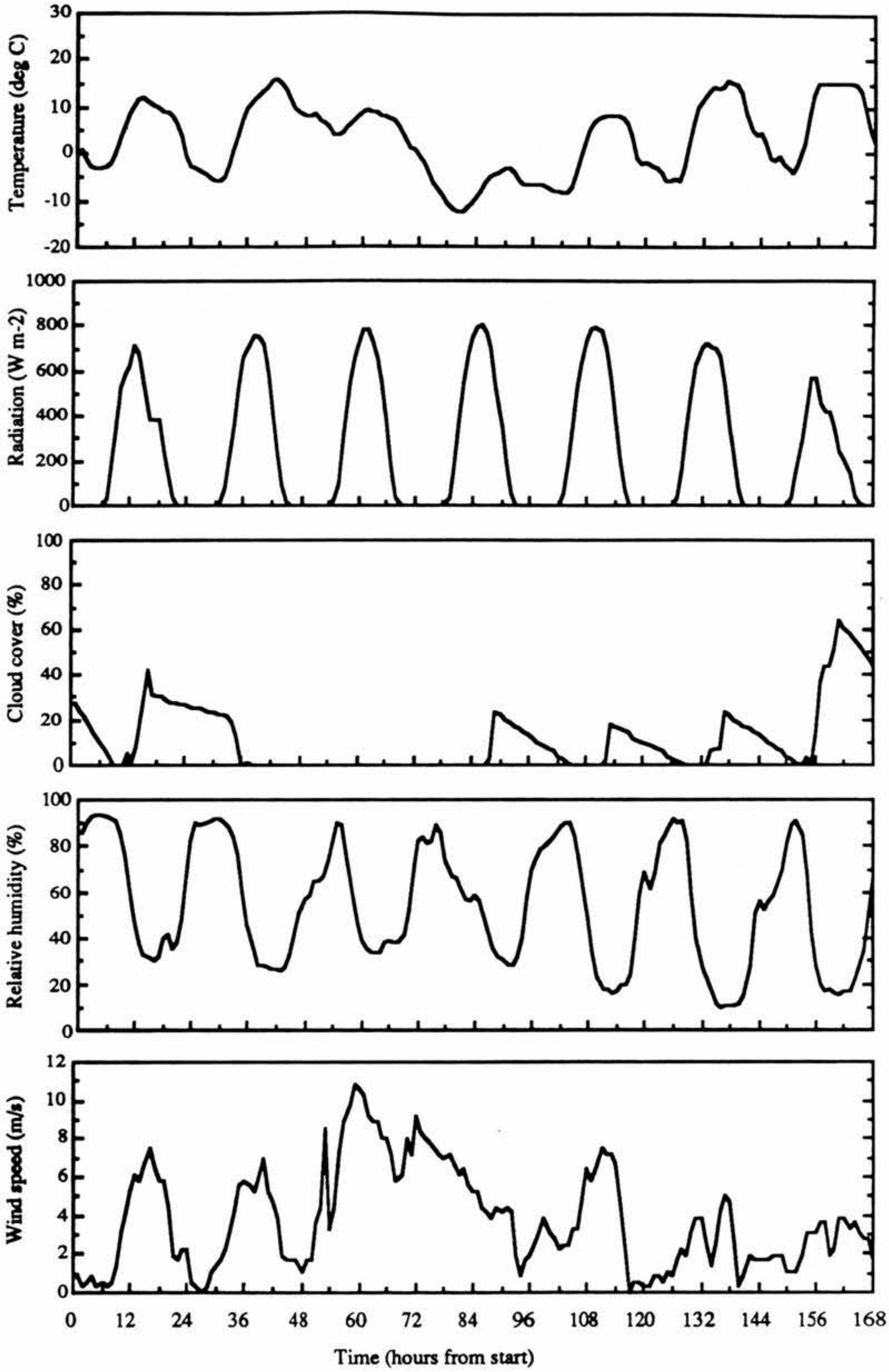


Figure A5.4 Hourly meteorological data at the Lunty site for week 4 (April 13-19, 1989)

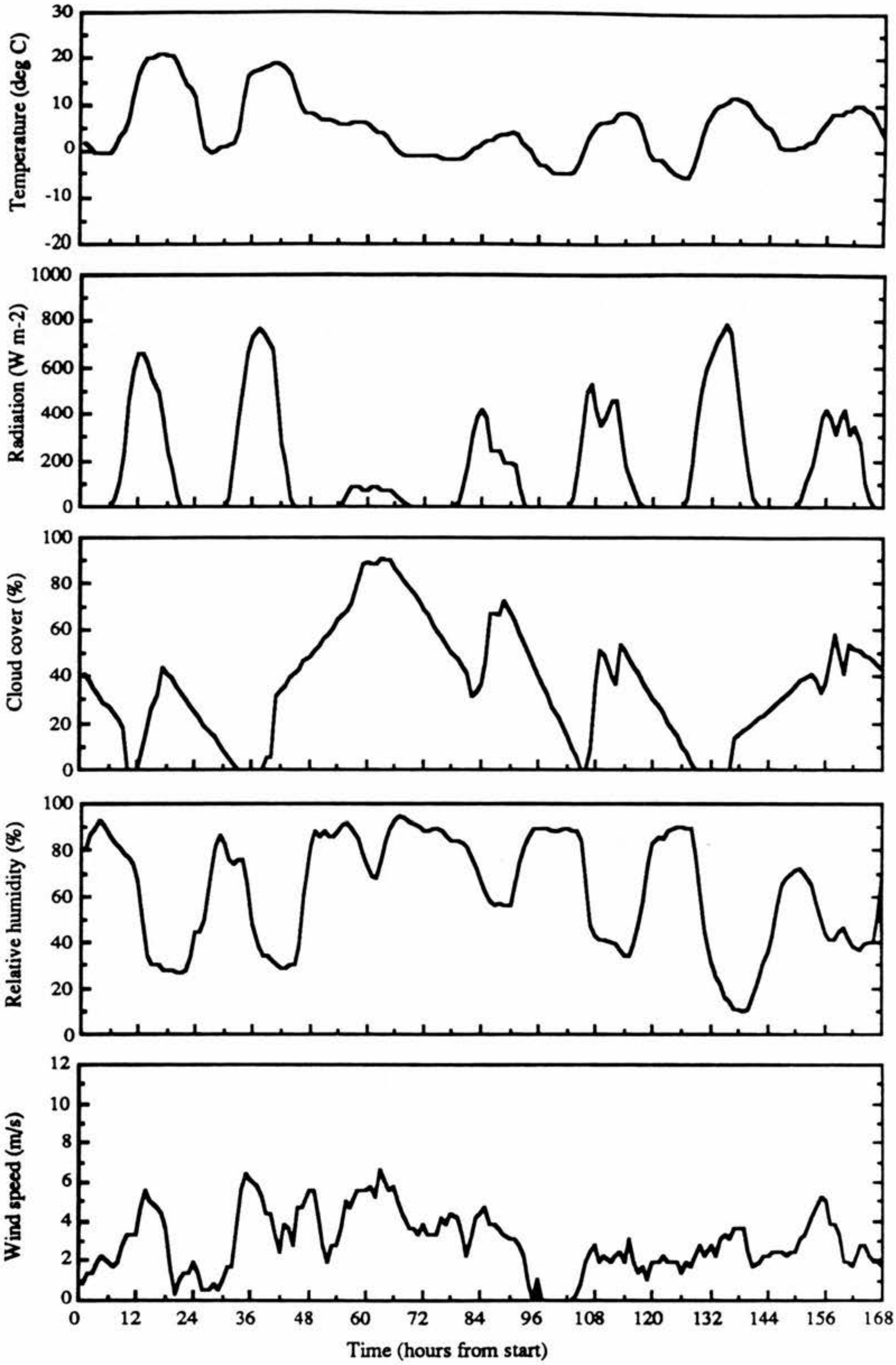


Figure A5.5 Hourly meteorological data at the Lunty site for week 5 (April 22-26, 1989)

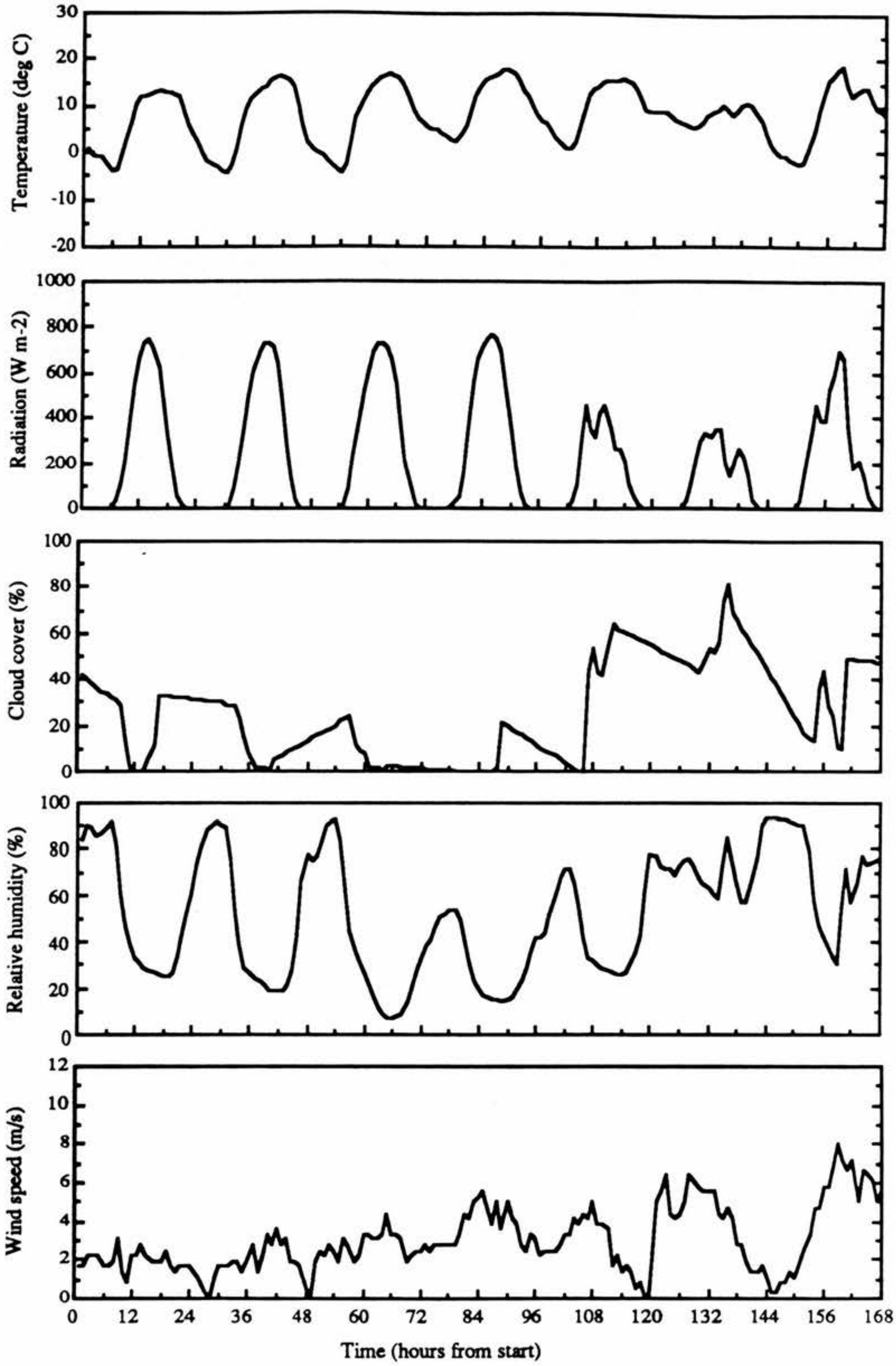


Figure A5.6 Hourly meteorological data at the Lunty site for week 6 (April 27 - May 3, 1989)

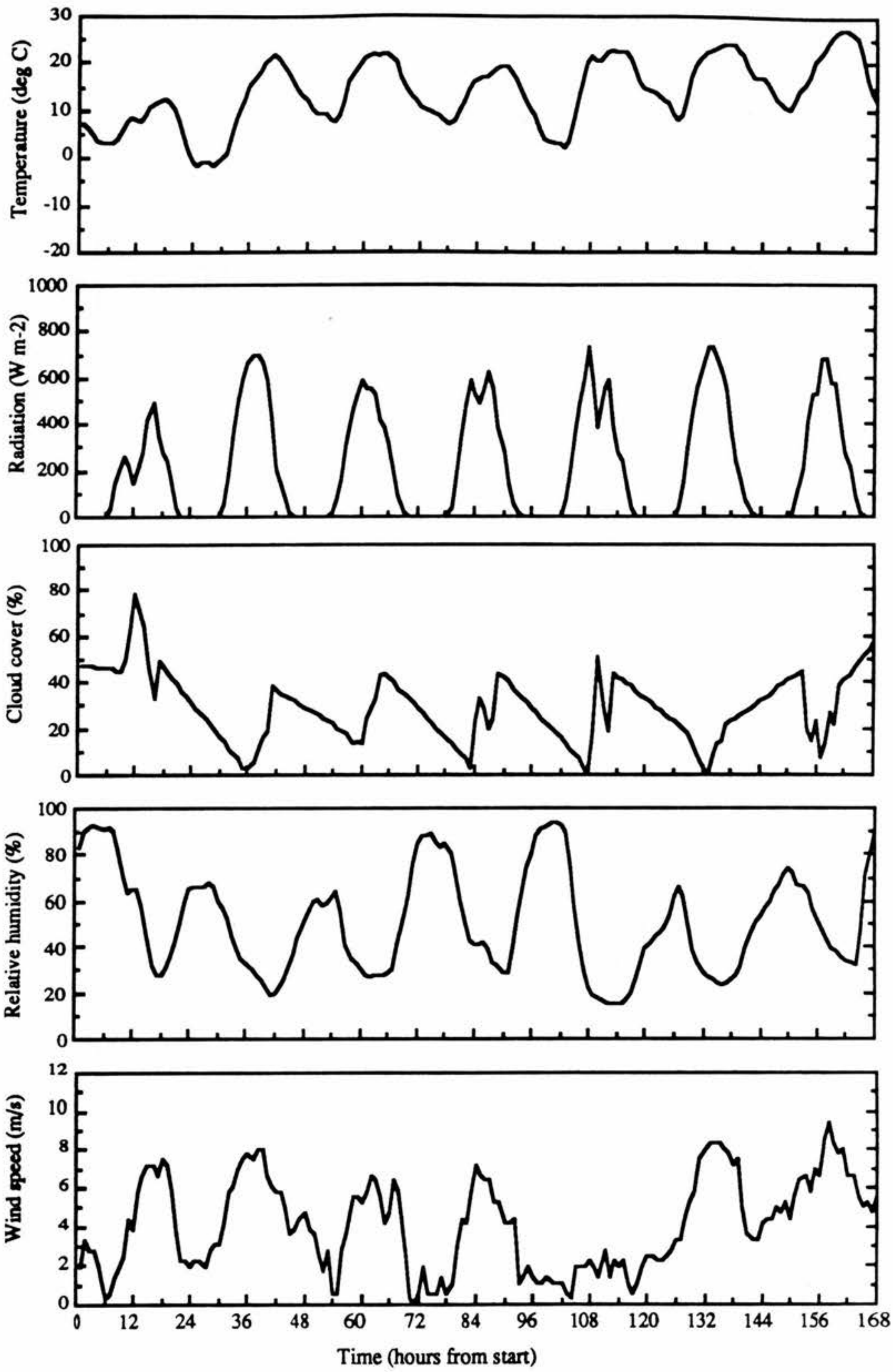


Figure A5.7 Hourly meteorological data at the Lunty site for week 7 (May 4-10, 1989)

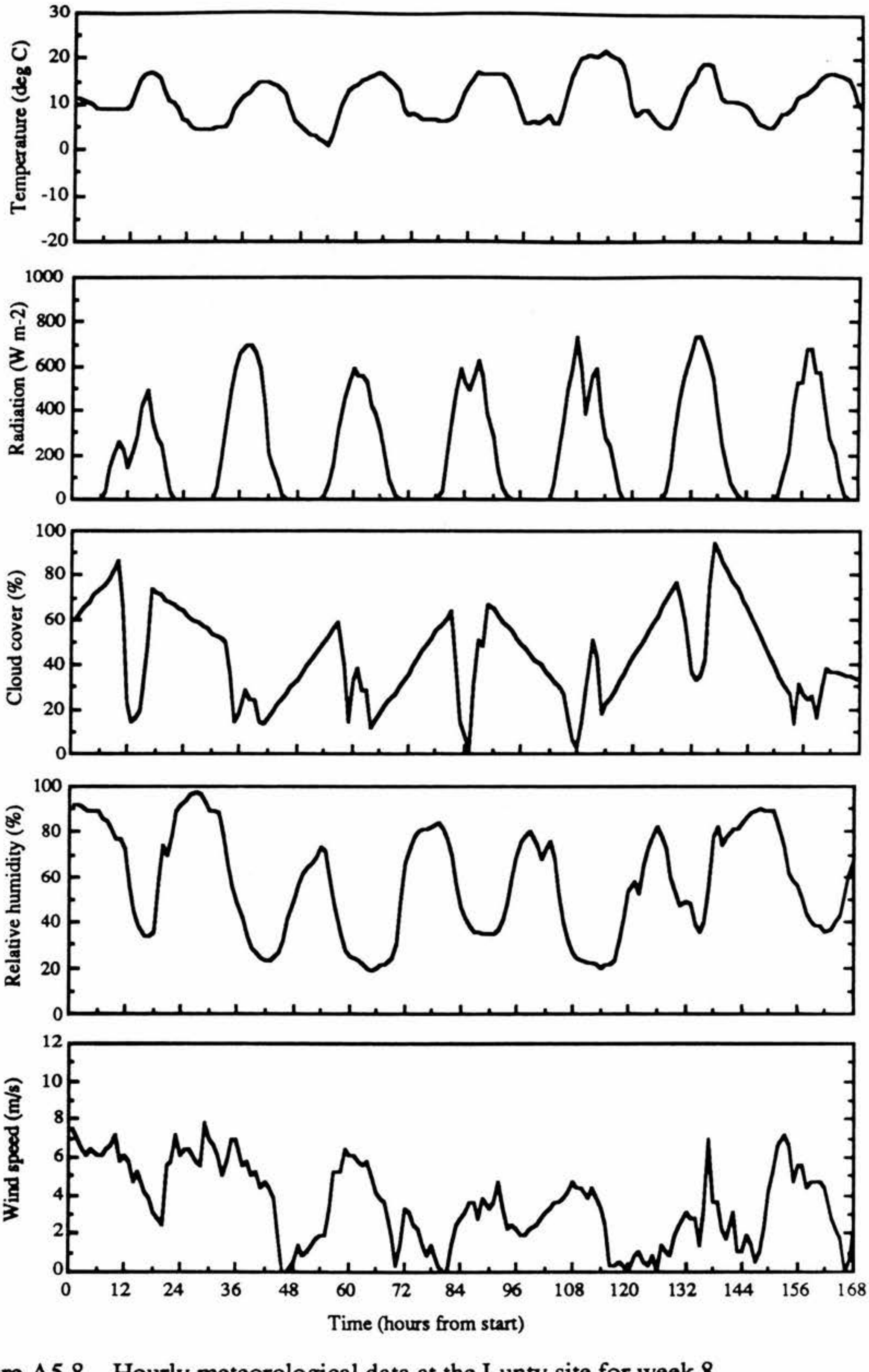


Figure A5.8 Hourly meteorological data at the Lunty site for week 8 (May 11-17, 1989)

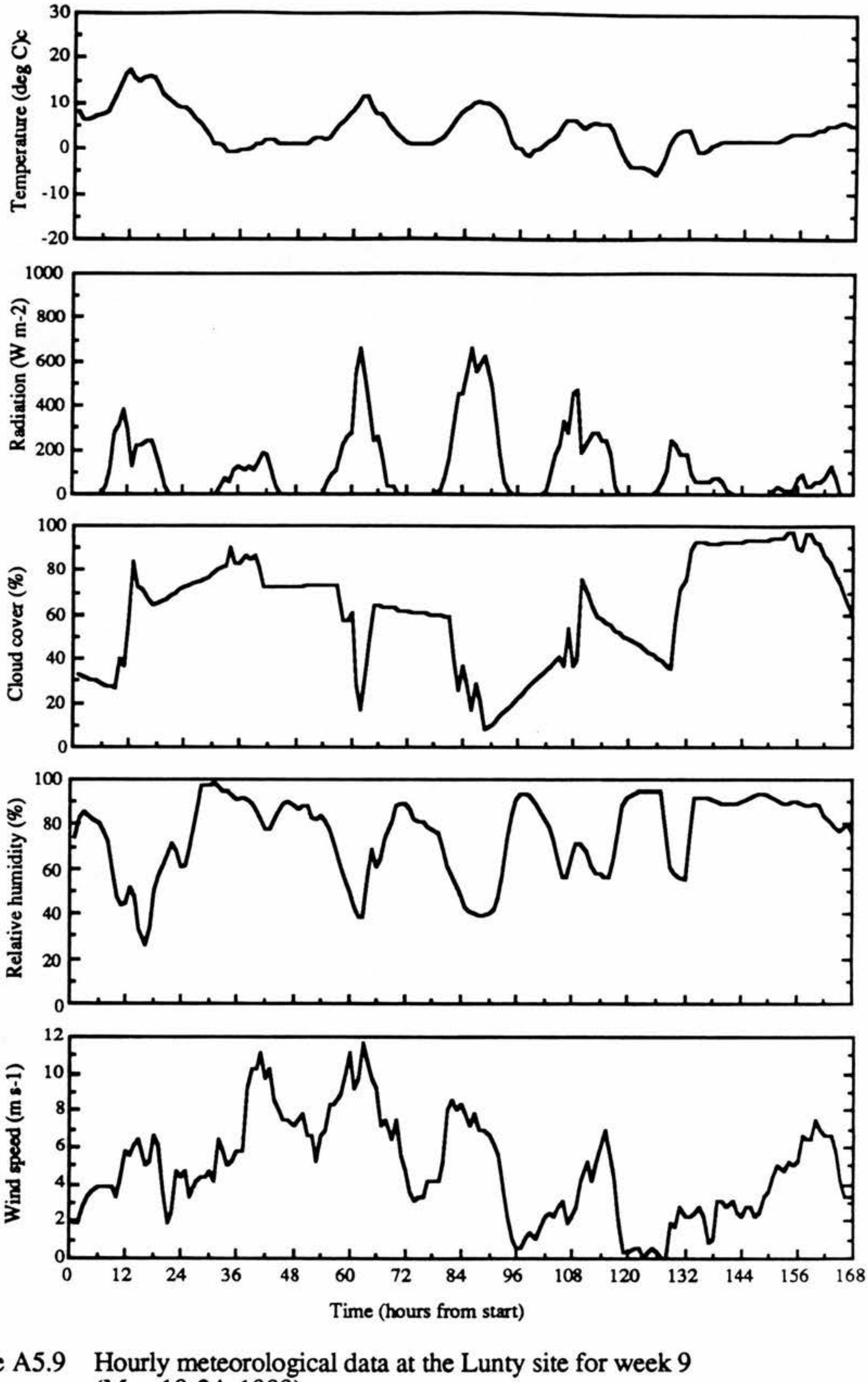


Figure A5.9 Hourly meteorological data at the Lunty site for week 9 (May 18-24, 1989)

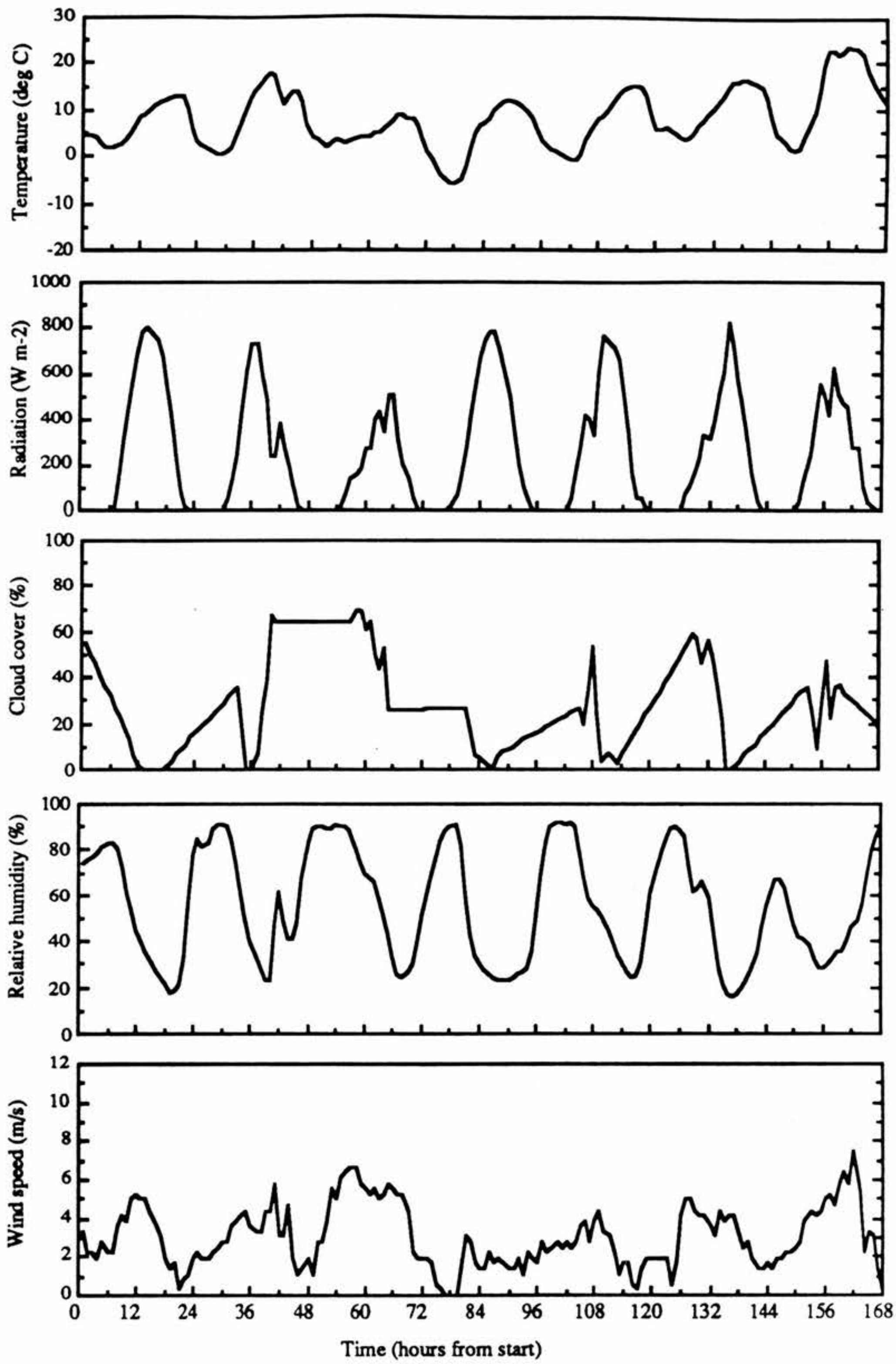


Figure A5.10 Hourly meteorological data at the Lunty site for week 10 (May 25-31, 1989)

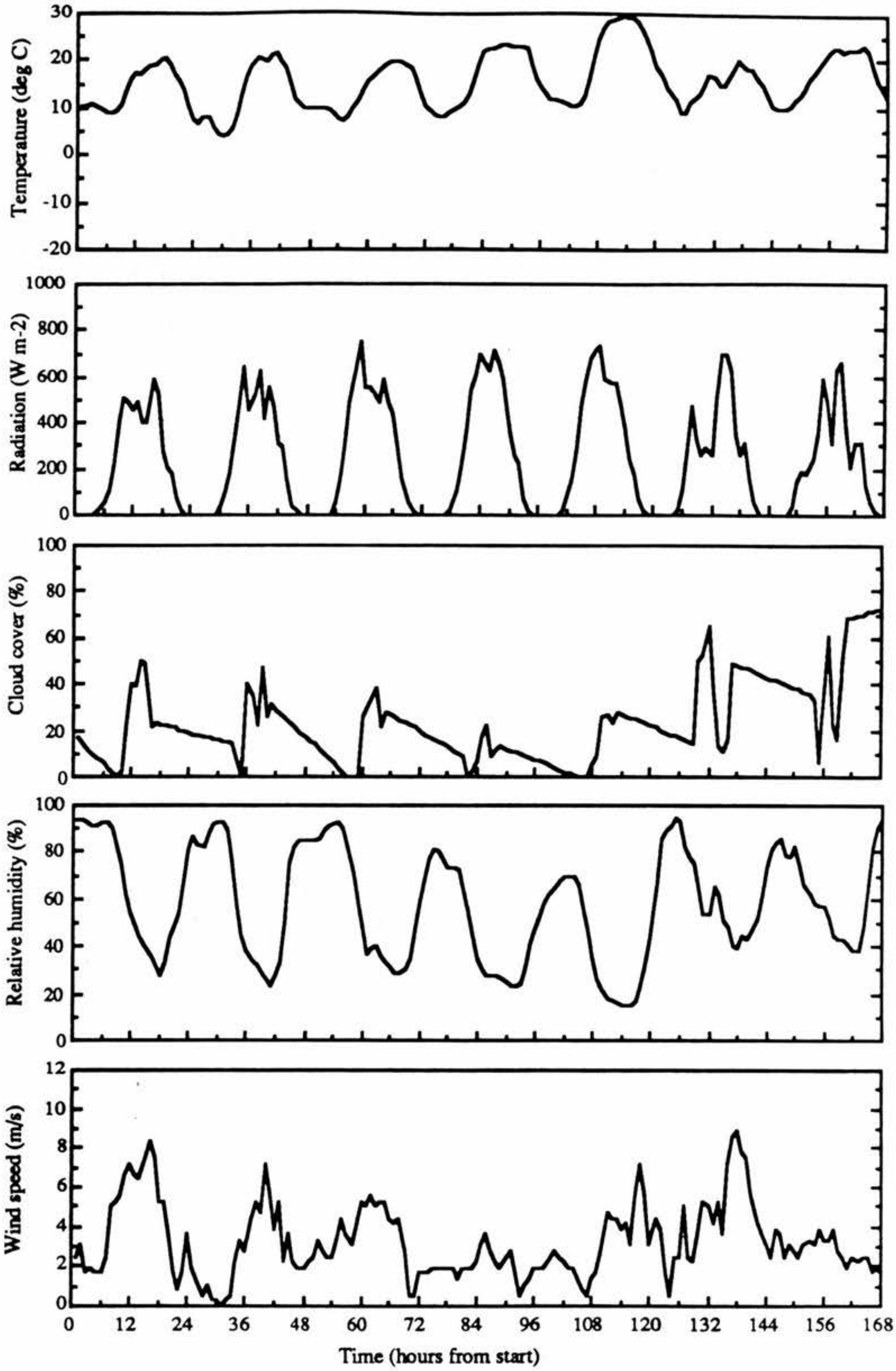


Figure A5.11 Hourly meteorological data at the Lunty site for week 11 (June 1-7, 1989)

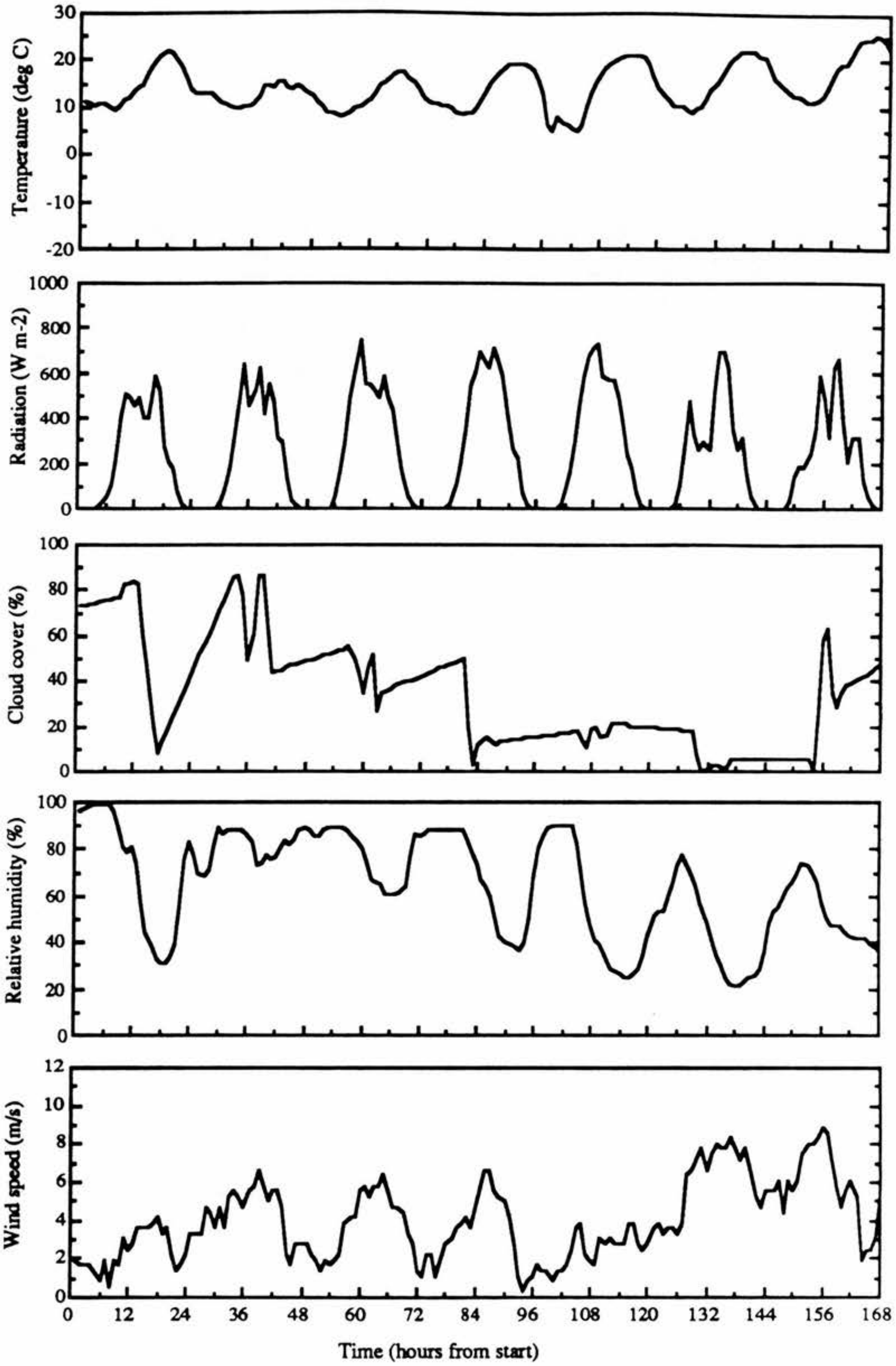


Figure A5.12 Hourly meteorological data at the Lunty site for week 12 (June 8-14, 1989)

APPENDIX 6

POND SURVEY DATA

RECORDED AT THE LUNTY SITE

A6.1 Introduction

This appendix contains a listing and a discussion of the data on pond location, extent and depth collected at the Lunty site for the 1989 field season. It presents the results of field surveys undertaken on 15 separate dates to record the location, extent and maximum elevation of ponding of all ponds present on any given date (Table A6.1).

The lowest elevation of each observed pond (called the pond centre elevation in Table A6.1) was surveyed and recorded once, usually after a given pond had dried up and disappeared. The depth of ponding was computed as the difference between the maximum pond surface elevation on any given date and the pond centre elevation. The DEM pit elevation represents the elevation of the lowest Lunty DEM grid cell in the watershed calculated to contain, and be associated with, each surveyed pond. In most cases, the physical x,y location of the surveyed pond centre and the computed pit centre were within 5 m (or one grid cell unit) of each other. The elevations of the surveyed pond centre and the calculated pit centre do not correspond exactly. Non-correspondence is due to the lower precision of the DEM (elevations were rounded to the nearest 10 cm) and to differences in the physical locations of the surveyed pond centre and the calculated DEM pit centre.

The DEM pond surface elevation was computed by adding the depth of ponding calculated for each pond at each date to the DEM pit elevation for the watershed (shed) associated with that pond. The DEM pond elevation is the elevation to which water would have to accumulate to "flood" the DEM to the same depth as recorded for the actual field surveyed ponds.

A pattern of appearance, growth and decay of each of the ponds extracted from the tabulated data is illustrated in Chapter 3 (Figures 3.13 to 3.15) and discussed below.

Snow covered much of the landscape on March 31 and prevented the observation or measurement of several ponds that may have been forming under the snow. The four (4) ponds noted on March 31 were all located in hollows in mid to upper landscape positions where the snow was absent, or at least thin enough to permit observation and recording of open water. Snow drifts in lower landscape positions obscured several of the larger central ponds. Other ponds had not yet begun to form as significant snowmelt had not yet occurred.

Most ponds had developed to their fullest extent by April 4, 1989. No rainfall was recorded from March 22 until April 7 so all of the ponding observed on April 4 must be ascribed to either surface runoff of melting snow or a sub-surface rise in the groundwater table. Data from companion studies (Trudell, 1992, personal communication) indicated that the soil was still frozen at this date and no significant increase in water table elevations had yet occurred. Surface runoff of melting snow is therefore concluded to be the sole contributor to initial pond formation. Exceptions to the dominant pattern of pond growth included pond 182 which was not recorded at this date due to deep snow drifts which persisted at this location and pond 3 which either never formed or was overlooked during the initial surveys. Ponds 6, 5 and 155 all exhibited a decrease in volume between March 31 and April 4. The observed decrease in volume at all three ponds was in excess of the volume that could be ascribed to evaporation. All three of these ponds were located in depressions in middle to upper landscape positions. These locations had the most shallow initial snow cover and were free of snow and beginning to experience soil warming earlier than lower landscape positions. Some of the reduction in volume of these ponds must be assigned to infiltration. The consequent conclusion is that the soil under these ponds thawed quite rapidly and accepted significant infiltration.

All ponds diminished in depth and size between April 4 and May 24, 1989. A total cumulative rainfall of 25.9 mm over that period was more than offset by a cumulative evaporation of 208.4 mm (Table A5.3). Several ponds had completely disappeared by May 3 and by May 24 only 6 ponds still contained any water.

On the April 12 survey date, all ponds except 182, 3 and 194 exhibited a reduction in volume in excess of the estimated loss due to evaporation. This indicates that some portion of the loss in pond volume must be assigned to infiltration into the soil below these ponds. Pond 183 was first recorded on this date so it is not possible to interpret whether it had increased or decreased in volume from the previous date. Pond 3 was again not recorded or had not yet formed. Pond 194 maintained its volume in the presence of an estimated potential evaporation of 114 m^3. The most likely explaination is that melting snow continued to provide additional runoff to this pond in excess of both evaporation and infiltration. The 4 mm of rain that fell on April 7 had no measureable effect on pond volumes.

By April 19 four ponds (8, 2, 5, 9-west) were completely dried up and no longer present. All of these were shallow ephemeral ponds in upper landscape positions. They had exhausted their supply of runoff from snowmelt and were receiving no subsurface throughflow or groundwater recharge. Their upper landscape locations favoured early melting of snow, early thawing of subsoils and rapid infiltration of accumulated ponding into the subsoil. All of the remaining ponds except 185-East exhibited a reduction in volume in excess of the estimated total losses from evaporation. It would appear that a considerable portion of the loss in volume of these ponds must be assigned to infiltration through the bottom of the ponds. Pond 185-East exhibited a reduction in volume less than expected from the calculated total evaporation. The most likely explaination for this behaviour is that ponds 185-East and 185-West were connected through either a non-visible culvert or groundwater flow. Water from pond 185-West likely flowed into pond 185-East to satisfy some of the evaporative demand from this pond. This explaination is supported by the fact that ponds 185 West and East maintained the same maximum elevation through all survey dates.

The pattern of reduction in pond volume continued from April 19 to April 26. Another upland pond (173) disappeared over this interval, while pond 2 reappeared, seemingly in place of 173 (the two ponds were located in close proximity). It is likely that water from pond 173 migrated to the pond 2 location, probably by near surface throughflow. The rate at which all of the ponds diminished in volume was considerably lower in the interval April 19-26 than in previous intervals. This was likely due to the fact that all ponds were smaller and had less surface area for evaporation and infiltration. It would also appear that iinfiltration below the ponds was slowing down as most of the loss in volume for this interval could be accounted for by the estimate of loss by evaporation. It is likely that the infiltration "store" below the ponds was filling up reducing the capacity for further infiltration.

The period from April 26 to May 3 displayed a continuation in the pattern noted above. Ponds 7, 3, 2 and 155 disappeared and were no longer recorded. All of these ponds were located in mid to upper landscape positions. They had no further source of input and were subject to rapid evaporation and infiltration. All of the remaining ponds were associated with larger catchments and were located in lower landscape positions. They were likely still receiving some input through sub-surface throughflow from higher elevations. This conclusion is supported by moisture monitoring data (Appendix 5) which displayed a continued increase in soil moisture content for soils in lower and toe slope positions well into May, after soils higher in the landscape had already begun to dry out. Both infiltration and evaporation are required to explain the reduction in volume observed at all remaining ponds. Infiltration continued to become less significant except for ponds 185 East and West where it increased in magnitude.

Pond 23 disappeared by May 10 and all remaining ponds continued to reduce in size and volume. Estimated evaporation explained most of the reduction in pond volume for these ponds. Ponds 182, 9-East and 189 disappeared by May 17 leaving only ponds 184, 185 East and West, 194, 157 and 197. The six remaining ponds were all located in major depressions in the lowest portions of the landscape. They were quite likely in contact with the saturated zone and likely continued to receive inputs from sub-surface flow.

The six semi-permanent ponds reached their minimum recorded extent and volume by May 24. Estimated evaporation was sufficient to explain most of the observed reduction in pond volume for the interval May 17-24. For all remaining ponds, the potential loss from evaporation was greater than the observed reduction in pond volume. Thus, no infiltration was required to explain the reduction in pond volume and a positive discharge into the ponds was required to explain why the ponds did not decrease in volume more than was observed. The 16 mm of rain which fell on May 24 may have contributed some surface recharge to the 6 remaining ponds thereby explaining the lower than predicted reduction in pond volumes.

The field survey conducted on June 6/89 was incomplete and the data are not analysed. The next survey date was July 4/89. On this date, four (4) of the ponds that had previously disappeared (182, 6, 155 and 189) re-appeared and were recorded. In addition, four (4) of the six (6) semi-permanent ponds increased in volume from the previous date. The observed increase in pond numbers and volume was clearly related to the 66 mm of rain that fell nearly continuously between June 9 and July 4/89. This rain obviously produced surface runoff which refilled the major mid and lower slope depressions.

Heavy rainfall resulted in a continued increase in the number and volume of ponds recorded on July 11/89. Two previously dry ponds (7 & 90) reappeared and all others (except 197) increased significantly in volume. The increase in volume was in excess of any losses due to evaporation or infiltration.

Four ponds (7, 157, 197, 9-East) disappeared altogether between July 11 and 25 and all remaining ponds decreased significantly in volume. A total of 6 mm of rain fell during this interval while evaporation was high (75.7 mm). At all ponds except 185 East and West evaporation was insufficient to explain all of the observed reduction in pond volume. Some infiltration is required to explain the loss in volume observed for these ponds. At ponds 185 East and West the reduction in volume was less than expected given the estimated potential evaporation. This indicates the liklihood that these two ponds received some net recharge from sub-surface flow. This provides further evidence that these two ponds were in contact with the water table.

Table A6.1 Original field survey data on pond location, elevation and depth with corresponding DEM grid locations & elevations

Survey Date	Pond Field ID Number	DEM Shed No.	Pond Centre Elev (m)	Pond Surface Elev (m)	Pond Depth (m)	DEM Pit Elev (m)	DEM Pond Surface Elev (m)
1989/03/31	6	23	722.566	722.871	0.305	722.7	723.0
1989/03/31	173	57	726.870	727.080	0.210	726.9	727.1
1989/03/31	5	58	726.825	727.045	0.245	726.8	727.0
1989/03/31	155	64	722.792	723.162	0.370	722.9	723.3
1989/04/04	7	4	723.670	724.100	0.430	723.7	724.1
1989/04/04	8	14	724.775	724.965	0.265	724.7	725.0
1989/04/04	184	19	721.974	722.409	0.509	721.9	722.4
1989/04/04	6	23	722.566	722.830	0.264	722.7	723.0
1989/04/04	185_EAST	35	721.855	722.120	0.420	721.7	722.1
1989/04/04	185_WEST	36	721.774	722.120	0.620	721.5	722.1
1989/04/04	1	50	726.990	727.050	0.150	726.9	727.1
1989/04/04	194	54	722.618	722.908	0.290	722.7	723.0
1989/04/04	173	57	726.870	727.170	0.300	726.9	727.2
1989/04/04	5	58	726.825	726.980	0.180	726.8	727.0
1989/04/04	155	64	722.792	723.114	0.322	722.9	723.2
1989/04/04	157	70	723.825	724.205	0.405	723.8	724.2
1989/04/04	197	83	725.066	725.331	0.431	724.9	725.3
1989/04/04	9_WEST	88	724.526	724.886	0.360	724.8	725.2
1989/04/04	9_EAST	90	724.091	724.466	0.375	724.2	724.6
1989/04/04	189	94	724.942	725.392	0.450	725.0	725.5
1989/04/12	7	4	723.670	724.035	0.365	723.7	724.1
1989/04/12	182	13	721.229	721.539	0.339	721.2	721.5
1989/04/12	8	14	724.775	724.870	0.170	724.7	724.9
1989/04/12	184	19	721.974	722.344	0.444	721.9	722.3
1989/04/12	6	23	722.566	722.806	0.240	722.7	722.9
1989/04/12	185_EAST	35	721.855	722.052	0.352	721.7	722.1
1989/04/12	185_WEST	36	721.774	722.050	0.550	721.5	722.1
1989/04/12	194	54	722.618	722.908	0.290	722.7	723.0
1989/04/12	173	57	726.870	726.990	0.120	726.9	727.0
1989/04/12	5	58	726.825	726.915	0.115	726.8	726.9
1989/04/12	155	64	722.792	723.067	0.275	722.9	723.2
1989/04/12	157	70	723.825	724.150	0.350	723.8	724.2
1989/04/12	197	83	725.066	725.256	0.356	724.9	725.3
1989/04/12	9_WEST	88	724.526	724.751	0.225	724.8	725.0
1989/04/12	9_EAST	90	724.091	724.431	0.340	724.2	724.5
1989/04/12	189	94	724.942	725.292	0.350	725.0	725.4
1989/04/19	7	4	723.670	723.940	0.270	723.7	724.0
1989/04/19	182	13	721.229	721.459	0.259	721.2	721.5
1989/04/19	184	19	721.974	722.274	0.374	721.9	722.3
1989/04/19	6	23	722.566	722.746	0.180	722.7	722.9
1989/04/19	185_EAST	35	721.855	722.045	0.345	721.7	722.0
1989/04/19	185_WEST	36	721.774	722.045	0.545	721.5	722.0

Table A6.1 Original field survey data on pond location, elevation and depth with corresponding DEM grid locations & elevations

Survey Date	Pond Field ID Number	DEM Shed No.	Pond Centre Elev (m)	Pond Surface Elev (m)	Pond Depth (m)	DEM Pit Elev (m)	DEM Pond Surface Elev (m)
1989/04/19	194	54	722.618	722.838	0.220	722.7	722.9
1989/04/19	173	57	726.870	726.880	0.010	726.9	726.9
1989/04/19	155	64	722.792	723.017	0.225	722.9	723.1
1989/04/19	157	70	723.825	724.095	0.295	723.8	724.1
1989/04/19	197	83	725.066	725.191	0.291	724.9	725.2
1989/04/19	9_EAST	90	724.091	724.386	0.295	724.2	724.5
1989/04/19	189	94	724.942	725.222	0.280	725.0	725.3
1989/04/26	7	4	723.670	723.885	0.215	723.7	723.9
1989/04/26	182	13	721.229	721.409	0.209	721.2	721.4
1989/04/26	184	19	721.974	722.229	0.329	721.9	722.2
1989/04/26	6	23	722.566	722.711	0.145	722.7	722.8
1989/04/26	3	34	726.965	727.015	0.215	726.8	727.0
1989/04/26	185_EAST	35	721.855	722.005	0.305	721.7	722.0
1989/04/26	185_WEST	36	721.774	722.005	0.505	721.5	722.0
1989/04/26	2	50	726.985	727.050	0.150	726.9	727.1
1989/04/26	194	54	722.618	722.768	0.150	722.7	722.9
1989/04/26	155	64	722.792	722.957	0.165	722.9	723.1
1989/04/26	157	70	723.825	724.080	0.280	723.8	724.1
1989/04/26	197	83	725.066	725.161	0.261	724.9	725.2
1989/04/26	9_EAST	90	724.091	724.361	0.270	724.2	724.5
1989/04/26	189	94	724.942	725.182	0.240	725.0	725.2
1989/05/03	182	13	721.229	721.349	0.149	721.2	721.3
1989/05/03	184	19	721.974	722.184	0.284	721.9	722.2
1989/05/03	6	23	722.566	722.676	0.110	722.7	722.8
1989/05/03	185_EAST	35	721.855	721.930	0.230	721.7	721.9
1989/05/03	185_WEST	36	721.774	721.930	0.430	721.5	721.9
1989/05/03	194	54	722.618	722.733	0.115	722.7	722.8
1989/05/03	157	70	723.825	723.940	0.140	723.8	723.9
1989/05/03	197	83	724.861	725.091	0.230	724.9	725.1
1989/05/03	9_EAST	90	724.091	724.296	0.205	724.2	724.4
1989/05/03	189	94	724.942	725.132	0.190	725.0	725.2
1989/05/10	182	13	721.229	721.304	0.104	721.2	721.3
1989/05/10	184	19	721.974	722.134	0.234	721.9	722.1
1989/05/10	185_EAST	35	721.855	721.875	0.175	721.7	721.9
1989/05/10	185_WEST	36	721.774	721.875	0.375	721.5	721.9
1989/05/10	194	54	722.618	722.718	0.100	722.7	722.8
1989/05/10	157	70	723.825	723.930	0.130	723.8	723.9
1989/05/10	197	83	724.861	725.036	0.175	724.9	725.1
1989/05/10	9_EAST	90	724.091	724.201	0.110	724.2	724.3
1989/05/10	189	94	724.942	725.042	0.100	725.0	725.1
1989/05/17	184	19	721.974	722.074	0.174	721.9	722.1
1989/05/17	185_EAST	35	721.855	721.870	0.170	721.7	721.9
1989/05/17	185_WEST	36	721.774	721.870	0.370	721.5	721.9

Table A6.1 Original field survey data on pond location, elevation and depth with corresponding DEM grid locations & elevations

Survey Date	Pond Field ID Number	DEM Shed No.	Pond Centre Elev (m)	Pond Surface Elev (m)	Pond Depth (m)	DEM Pit Elev (m)	DEM Pond Surface Elev (m)
1989/05/17	194	54	722.618	722.638	0.020	722.7	722.7
1989/05/17	157	70	723.825	723.890	0.090	723.8	723.9
1989/05/17	197	83	724.861	725.021	0.160	724.9	725.1
1989/05/24	184	19	721.974	722.069	0.169	721.9	722.1
1989/05/24	185_EAST	35	721.855	721.865	0.165	721.7	721.9
1989/05/24	185_WEST	36	721.774	721.865	0.365	721.5	721.9
1989/05/24	194	54	722.618	722.638	0.020	722.7	722.7
1989/05/24	157	70	723.825	723.890	0.090	723.8	723.9
1989/05/24	197	83	724.861	725.016	0.155	724.9	725.1
1989/06/01	157	70	723.825	723.850	0.050	723.8	723.9
1989/06/01	197	83	724.861	724.951	0.090	724.9	725.0
1989/07/04	182	13	721.229	721.339	0.139	721.2	721.3
1989/07/04	184	19	721.974	722.169	0.269	721.9	722.2
1989/07/04	6	23	722.566	722.841	0.275	722.7	723.0
1989/07/04	185_EAST	35	721.855	721.875	0.175	721.7	721.9
1989/07/04	185_WEST	36	721.774	721.875	0.375	721.5	721.9
1989/07/04	194	54	722.618	722.718	0.100	722.7	722.8
1989/07/04	155	64	722.792	723.027	0.235	722.9	723.1
1989/07/04	157	70	723.825	723.850	0.050	723.8	723.9
1989/07/04	197	83	724.861	724.901	0.040	724.9	724.9
1989/07/04	189	94	724.942	725.172	0.230	725.0	725.2
1989/07/11	7	4	723.670	723.875	0.205	723.7	723.9
1989/07/11	182	13	721.229	721.429	0.229	721.2	721.4
1989/07/11	184	19	721.974	722.239	0.339	721.9	722.2
1989/07/11	6	23	722.566	722.861	0.295	722.7	723.0
1989/07/11	185_EAST	35	721.855	721.930	0.230	721.7	721.9
1989/07/11	185_WEST	36	721.774	721.930	0.430	721.5	721.9
1989/07/11	194	54	722.618	722.778	0.160	722.7	722.9
1989/07/11	155	64	722.792	723.102	0.310	722.9	723.2
1989/07/11	157	70	723.825	723.885	0.085	723.8	723.9
1989/07/11	197	83	724.861	724.901	0.040	724.9	724.9
1989/07/11	9_EAST	90	724.091	724.296	0.205	724.2	724.4
1989/07/11	189	94	724.942	725.247	0.305	725.0	725.3
1989/07/25	182	13	721.229	721.304	0.104	721.2	721.3
1989/07/25	184	19	721.974	722.114	0.214	721.9	722.1
1989/07/25	6	23	722.566	722.746	0.180	722.7	722.9
1989/07/25	185_EAST	35	721.855	721.900	0.200	721.7	721.9
1989/07/25	185_WEST	36	721.774	721.900	0.400	721.5	721.9
1989/07/25	194	54	722.618	722.673	0.055	722.7	722.8
1989/07/25	155	64	722.792	722.997	0.205	722.9	723.1
1989/07/25	189	94	724.942	725.152	0.210	725.0	725.2
1989/08/10	184	19	721.974	721.994	0.094	721.9	722.0

Table A6.1 Original field survey data on pond location, elevation and depth with corresponding DEM grid locations & elevations

Survey Date	Pond Field ID Number	DEM Shed No.	Pond Centre Elev (m)	Pond Surface Elev (m)	Pond Depth (m)	DEM Pit Elev (m)	DEM Pond Surface Elev (m)
1989/08/10	6	23	722.566	722.661	0.095	722.7	722.8
1989/08/10	185_EAST	35	721.855	721.870	0.170	721.7	721.9
1989/08/10	185_WEST	36	721.774	721.870	0.370	721.5	721.9
1989/08/10	155	64	722.792	722.882	0.090	722.9	723.0
1989/08/10	189	94	724.942	725.057	0.115	725.0	725.1
1989/08/21	6	23	722.566	722.621	0.055	722.7	722.8
1989/08/21	155	64	722.792	722.842	0.050	722.9	723.0
1989/08/21	189	94	724.942	725.037	0.095	725.0	725.1

APPENDIX 7

THE SNOWMELT SUB-MODEL

7.1 Explaination of the algorithms and logic used in the snowmelt sub-model

This appendix describes the equations and computational logic used to estimate the volume of snowmelt for any given time step for a snow pack of given initial depth. The description is a résumé of that presented by Williams (1988) and large sections of the following text are reproduced verbatum from that report with the knowledge and approval of the original author. The mathematical formula, underlying assumptions and innput requirements associated with the computations for estimating snowmelt are discussed below. A complete listing of the computer code used to implement the equations follows the discussion.

Snow melt is computed using a modification of the energy balance equation as described by Male (1980) and implemented by Williams (1988) according to:

$$\frac{\partial S}{\partial t} = Q_s + Q_a + Q_e + Q_h + Q_v \quad \textbf{(A7.1)}$$

where $\partial S/\partial t$ is the rate of change of heat storage associated with changes in snow temperature, melting or freezing, and the energy flux densities Q, expressed in W m^{-2} and positive if energy is directed into the snow, include:

Q_s = absorbed short wave radiation
Q_a = longwave radiation from the atmosphere
Q_e = longwave radiation emitted from the snow surface
Q_h = convective transfer of sensible heat between the air and surface
Q_v = latent heat transfer between the air and surface by evaporation, condensation and sublimation

The following additional equations are used to estimate the magnitudes of the individual component energy fluxes where actual site measurements are not available.

7.1.1 Absorbed (incoming) short wave radiation Q_S

Absorbed shortwave radiation (Q_S) is computed as a fraction of the total measured incoming direct and diffuse shortwave radiation reduced in proportion to the albedo of the surface snow cover according to:

$$Q_s = (1-\alpha)G \tag{A7.2}$$

where α is the albedo of snow and G is the measured incoming global radiation in W m^2. The albedo of the surface changes dramatically as the snow pack thins and eventually disappears, varying from a high of 0.74 - 0.80 for clean, new snow to 0.13 - 0.17 for exposed bare soil. This variation is estimated using an equation proposed by Marshall and Warren (1987) as:

$$\alpha = \frac{\alpha_{\max} - (\alpha_{\max} - \alpha_g)}{(a\rho h + 1)^b} \tag{A7.3}$$

where α_{max} is a maximum albedo for the snow surface, α_g is the albedo of the underlying bare soil surface, ρh is the water equivalent of the snow and a and b are model coefficients obtained by Marshall and Warren (1987) for a least squares fit to observational data. Marshall and Warren (1987) suggested values of a=0.45 and b=2.25. The coefficients were apparently developed for water equivalent expressed in cgs units so an adjustment is made in the present implementation to compensate for water equivalent expressed in SI units.

7.1.2 Incoming long wave (atmospheric) radiation Q_a

Incoming longwave radiation from the atmosphere is estimated as a function of air temperature, clear sky emmissivity (as controlled by relative humidity and air temperature) and cloud cover according to:

$$Q_a = (1 + kN^2)\varepsilon_a \sigma T_a^4 \tag{A7.4}$$

where N is the cloud cover fraction estimated from the degree of depression of the observed global radiation relative to a theoretical maximum for the given time and place, ε_a is the effective clear sky emmissivity estimated as detailed below, s is the Stefan-

Boltzman constant (5.6697 x 10^{-8} W m^{-2}°K^{-4}) and T_a is the air temperature (°K). Atmospheric emmissivity is estimated from temperature and relative humidity data according to the Brunt formula as:

$$\varepsilon_a = 0.68 + 0.0036\sqrt{\varepsilon_a} \qquad \textbf{(A7.5)}$$

where e_a is the actual vapour pressure and the coefficients for the Brunt equation are derived from the literature for work conducted by Male and Granger (1979) at Bad Lake Saskatchewan. e_a is estimated according to:

$$\varepsilon_a = RH * esat(T_a) \qquad \textbf{(A7.6)}$$

where $esat(T_a)$ is an emperical equation used to estimate the saturation vapour pressure over water at the given atmospheric temperature (T_a). $esat(T_a)$ is calculated according to:

$$esat(T_a) = 610.7^{\frac{(17.491(T_a - 273.15))}{(T_a - 32.48)}} \qquad \textbf{(A7.7)}$$

7.1.3 Long wave radiation emitted from the snow surface Q_e

The long wave radiation emitted by the soil surface (Q_e) is calculated from the Stephan-Boltzman law as a function of snow surface temperature and emissivity according to:

$$Q_e = -\varepsilon_s \sigma T_s^4 \qquad \textbf{(A7.8)}$$

where ε_s is the emissivity of snow and is taken as 0.97, s is the previously reported Stefan-Boltzman constant and T_s is the surface temperature of the snow (°K). Significant variation in net long wave radiation can necessitate adjustment of the above formulas in areas of high relief Male (1980). For the present research, the landscapes of interest are assumed to be relatively flat and no adjustments are made.

7.1.4 Turbulent transfer of sensible Q_h and latent Q_m heat

The turbulent fluxes of sensible (Q_h) and latent heat (Q_v) tend to be considerably smaller than the radiation fluxes (Male, 1980). They may nevertheless play an important role in determining the final rate of melt of the snow cover. The sensible heat (Q_h) and latent heat (Q_v) fluxes are calculated using equations given by Anderson (1976) according to:

$$Q_h = F_h C_n \rho_a c_p u (T_a - T_s) \quad \textbf{(A7.9)}$$

and

$$Q_v = F_v C_n (0.622 \rho_a L u / p)(e_a - e_s) \quad \textbf{(A7.10)}$$

where C_n is a bulk transfer coefficient for neutral stability calculated by:

$$C_n = \left(\frac{\kappa}{\ln\left(\frac{z_u}{z_0}\right)} \right)^2 \quad \textbf{(A7.11)}$$

where κ is the von Karmen constant (0.4), z_u is the height at which wind speed is measured, and z_o is an emperical constant called the roughness length which is taken as 0.1 cm. The bulk transfer coefficient can be adjusted, if necessary, by varying the value selected for z_o.

F_h is a correction factor for departures from neutral stability. There is general agreement (Anderson, 1976) that F_h is unity within the stable range of conditions characteristic of neutral stability which is common over a melting snow surface. For departures from neutral stability F_h is taken as:

$$F_h = (1 - 5R_i)^2 \qquad \text{for } R_i > 0 \quad \textbf{(A7.12)}$$

$$F_h = (1 - 40R_i)^{1/4} \qquad \text{for } R_i < 0 \quad \textbf{(A7.13)}$$

where R_i is the bulk Richardson number calculated according to:

$$R_i = \frac{g z_a (T_a - T_s)}{u^2 (T_a + T_s)/2} \quad \textbf{(A7.14)}$$

in which g is the acceleration of gravity, u is the wind speed and z_a is the height at which temperature is measured (assumed 1.5 m). F_v is calculated as $F_h/2$ based on measurements by Male and Granger (1981).

The other parameters in the above equations are air density ρ_a, specific heat at constant pressure c_p, the latent heat of sublimation or vaporisation L, air pressure p and the vapour pressures in air (e_a) and at the snow surface (e_s).

The first three parameters above are taken as constants with values of:

ρ_a = 1.225 kg m^{-3}
c_p = 1005 J kg^{-1} °K^{-1}
L = 2.835 J kg^{-1}

Air pressure (in Pascals) may be input directly or may be approximated according to:

$$P = P_0^{(-0.034H/T_a)} \tag{A7.15}$$

where P_0 is taken as 1.013x10^5 Pa and H is elevation above sea level.

The saturation vapour pressure over water e_{sat} is calculated according to a least squares fit to published values according to:

$$e_{sat} = 610.7 \exp 17.491 \frac{(T_a - T_m)}{(T_a - 32.48)} \tag{A7.16}$$

where T_m is the melting temperature of ice (273.15 °K). The vapour pressure at the snow surface e_s is taken as the saturation vapour pressure over ice according to the least squares fit:

$$e_s = 610.64 \exp 22.457 \frac{(T_s - T_m)}{(T_s - 0.56)} \tag{A7.17}$$

7.2 Solving for changes in heat storage

Theoretically, the heat storage of a snowcover is:

$$\int_0^h (\rho_z c T_{zl} + L_f w) \partial z \tag{A7.18}$$

where h = snow depth, ρ_z = snow density (kg m^{-3}), c = specific heat capacity of ice (J kg^{-1} °K^{-1}), T_z = snow temperature at depth z (°K), L_f = latent heat of fusion (J kg^{-1}), w = liquid water content of the snow (kg m^{-3}) and z = the height above ground (m).

Normally, insufficient information is available to determine the profiles of ρ_z, T_z and w through the entire depth of a snow pack. In such cases, a simpler approach is to account for the bulk changes in heat storage for the entire snow pack. For this purpose it is convenient to express heat storage S relative to melting temperature T_m rather than absolute zero. Williams (1988) provides the following formula for this approximation:

$$S = \bar{\rho} hc\left(\bar{T} - T_m\right) + L_f W \qquad \textbf{(A7.19)}$$

where $\bar{\rho}$ is the mean snow density, h is the depth of snow (m), c is the specific heat as above, $\bar{T}$ is the mean snow temperature, T_m is the melting temperature and W is the liquid water content in the snow.

The heat storage term will be negative ($S < 0$) whenever the average snow temeperature is less than the melting temperature ($\bar{T} < T_m$) and the liquid water content is zero ($W = 0$). The heat storage becomes positive ($S > 0$) whenever the average snow temperature equals the melting temperature ($\bar{T} = T_m$) and the liquid water content exceeds zero ($W > 0$).

The mean snow temperature ($\bar{T}$) is arbitrarily computed by linear interpolation between the temperature at the base of the snow (T_o) and at the snow surface (T_s) according to the formula:

$$\bar{T} = \frac{\left(T_s - T_0\right)}{2} \qquad \textbf{(A7.20)}$$

This interpolation assumes that the snow surface temperature T_s is less than the melting temperature and that T_s and T_o are known or can be estimated for at least the initial time step.

In subsequent time steps, the value for T_o is neglected since it can be assumed that diurnal changes in T_o are negligible compared with those at the snow surface (T_s). The rate of change in S between time steps *i-1* and *i* is therefore calculated according to:

$$\partial S / \partial t = \frac{\bar{\rho} hc\left(T - T_{i-1}\right)}{2\Delta t} \tag{A7.21}$$

where T_i is the snow surface temperature at time i and Δt is the time step (3600 seconds or one hour).

A positive melt rate (M) occurs whenever the snow surface temperature T_s exceeds the melting temperature T_m. The volume of melt water produced in any given time step is equal to the sum of the terms in the energy balance equation (A7.1) divided by the latent heat of fusion (L_f). However the heat storage term S may still be negative if some of the snow beneath the surface is at temperatures below freezing. In such cases, any meltwater that percolates into the snow will refreeze, releasing latent heat which warms the underlying frozen snow. This has the effect of increasing the heat storage term S by an amount $L_f M \Delta t$, until S=0 at which point the snow is isothermal at 0 °C.

Melt water is initially released into the snow and allowed to fill voids and pores until the snow is deemed to be saturated. Melt water drains from the snow onto the soil surface only once the total liquid water content W exceeds a limiting value determined by the liquid water holding capacity (W_c) of the snow. The liquid water holding capacity is arbitrarily set to 5% by volume according to suggestions by Anderson (1976). Once W reaches W_c, any further production of meltwater is assumed to drain from the snow and the snow water equivalent ρh is reduced by that amount.

7.3 Limitations and neglected terms

The heat advected by rain falling on snow is much smaller than the other energy fluxes and has been omitted. If rain falls on frozen snow its effect on S through latent heat released by freezing can be substantial. This is considered to be a sufficiently infrequent event that it is ignored. Rain on wet snow would increase W so that the saturation value W_c would be reached sooner but this is expected to be a minor effect.

The other term missing from the main energy balance equation (A7.1) is the heat flux at the snow-ground interface. This flux occurs mainly by conduction. It is neglected because it is not possible to accurately determine the temperature gradient and thermal conductivities of snow and ground. Over hourly intervals this component is negligible compared with the energy fluxes at the snow surface.

Male and Granger (1979) indicated that equations for sensible and latent heat flux based on simplified bulk transfer coefficients as detailed above can be subject to considerable error. They showed that, although there was a correlation between daily totals of sensible heat as calculated by the bulk transfer equation and a more rigourous approach, significant differences could exist on any given day. They concluded that the bulk transfer formula is a poor estimator of latent heat flux but noted that use of simplified equations in operational forcasts was possible because, "in many field situations, the sensible and latent heat fluxes are of secondary importance compared to the radiation flux".

Male (1980) cited a number of limitations on using the turbulent flux equations imposed by assumptions inherent in the method. Such equations should only be used in relatively flat, open areas where the assumption of one-dimensional heat flow implicit in the methods is valid. They should be applied to large areas of continuous snow cover in the absence of appreciable bare soil, forest cover or nearby body of water over which the air can be warmed. This requires an upstream fetch of several hundred meters.

Complications arise when dealing with the thin, discontinuous snow cover characteristic of the relatively flat prairie and tundra regions of the northern hemisphere (Male, 1980). Local advection from bare patches to the snow can make a significant contribution to snowmelt, especially as the snow cover dwindles. It has been reported (Gray and O'Neill, 1974) that up to 44% of the energy supplied to an isolated melting snowpatch over a six day period was from sensible heat transfer while during the period of continuous snowcover the corresponding figure for the same location was 7%. Despite these reservations, other studies have shown that one dimensional equations for turbulent transfer can give reasonable results if patches of snow attain minimum dimensions of 250 m long by 100 m wide (Cox and Zuzel, 1976) and if temperatures and vapour pressures are measured near the centre of the patch (Weisman, 1977).

7.4 Computational procedure

Unlike the original program by Williams (1988) this implimentation does not allow for additions of new snow to the snow pack nor does it account for changes in heat storage (S) arising from the addition of new snow. The present program is limited to the computation of water yield from a melting snow pack of given initial depth and density.

Computations are begun at some arbitrary starting point near the end of March. It is assumed that snowmelt has not yet begun to occur and that there is no liquid water present in the snow. An average snow temperature $\overline{T}$ at time t_0 is estimated for the snow pack based on estimates for the temperature at the soil surface T_o and the snow surface T_s. The ground surface temperature (T_o) is taken to be equal to the soil temperature measured by a soil probe at 5 cm. The snow surface temperature (T_s) is taken to be equal to the air temperature at midnight on the starting day. The density of the snow is arbitrarily set to an appropriate value in the range of 200 to 220 kg m^{-3} according to observations made by Zebarth and De Jong (1989).

The heat storage of the soil pack at time t_0 is computed using the estimate of initial average snow temperature $\overline{T}$ according to:

$$S = \overline{T} * \rho * h * cs \qquad \textbf{(A7.21)}$$

where cs is the specific heat capacity of dry snow. The initial water equivalent of the snow pack is computed as $WE = \rho * h$. The albedo of the snow surface is computed as a function of the snow depth and density relative to appropriate maximum and minimum values for dry snow and bare soil.

The program is set up to estimate snow melt for a fixed number of arbitrary depths of snow ranging from 5 to 200 cm. For each initial depth of snow, the program steps through the daily meterological input data at hourly intervals. At each time step i (i = 1,...,24), the program initially solves for the snow surface temperature (T_i) at the new time step. T_i is assumed to be less than T_m and the energy balance equation with energy flux densities Q given by equations (2,3,4,8,9,10) above and $\partial S/\partial t$ by (21) is solved for T_i by Newton-Raphson iteration. If T_i is, in fact, less than T_m, the heat storage term S is altered by the amount $\partial S/\partial t$ which may be either positive or negative depending upon whether there was a net input or loss of energy from the snow surface. However, if the solution estimates the surface temperature to be greater than the melting temperature ($T_i > T_m$), then T_i is set equal to T_m and the right side of equation (A7.1) is recomputed with that value to give ΣQ, and S is incremented by $\Sigma\, Q\, \Delta t$. If S exceeds a saturation value $S_{max} = L_f W_c$, the snow water equivalent ρh is decremented by $(S\text{-}S_{max})/L_f$ and S is set equal to a revised value of S_{max}.

The amount by which the snow water equivalent is decremented is taken as the *LOSS* of water from the snow pack for that time step, where $LOSS = (S\text{-}S_{max})/L_f$ measured in kg

m^{-2}. Since 1 mm of water over an area of 1 m^2 weighs 1 kg the value computed as *LOSS* in kg m^{-2} translates directly into input in mm m^{-2} which is the unit of measure used for input in the main distributed runoff model.

NOTE: 1 cm^3 = 1 gm, 10^4 cm in 1 m^2 results in 10^4 gm or 10 kg water over a depth of 1 cm, therefore 1 mm = 0.1*10 = 1 kg water).

For any time step with a positive value for *LOSS,* the computed *LOSS* is stored in an appropriate column in a data base table. All time steps are processed for a given initial snow depth until such time as all of the initial snow has melted (ie *WE*=0). Once all of the snow has melted for a given initial depth, the program goes back to the top of the meteorological data file, sets a new value for initial snow depth and recomputes the hourly surface temperature and potential melt volume for each time step for that starting snow depth. This is repeated until snow melt has been computed for all of the arbitrarily defined initial snow depths.

7.5 References

Anderson, E. A. 1976. NOAA Technical Report. NWS 19. 150 pp.

Cox, L. M. and J. F. Zuzel. 1976. Proc. 44th. Annu. Meet. West. Snow Conf. pp. 23-28.

Gray, D. M. and A. D. J. O'Neill. 1974. ***In:*** Advanced concepts and techniques in the study of snow and ice resources. (H. S. Santeford and J. L. Smith eds.) Natl. Acad. Sci. Washington. D. C. pp 108-118.

Male, D. H. 1980. The seasonal snow cover. ***In:*** Dynamics of snow and ice. S. C. Colbeck (ed). Academic Press. London. pp. 303-395.

Male, D. H. and R. J. Granger. 1979. Energy mass fluxes at the snow surface in a prairie environment. ***In:*** Proceedings of modelling snow cover runoff (S. C. Colbeck and M. Ray, eds). U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire. pp. 101-124.

Male, D. H. and R. J. Granger. 1981. Snow surface energy exchange. **Water Resources Research.** 17: 609-627.

Marshall, S. E. and S. G. Warren. 1987. Parameterization of snow albedo for climate models. ***In:*** Large scale effects of seasonal snow cover. B. E. Goodson, R. G. Barry and J. Dozier (editors). Proceedings of the Vancouver Symposium. IAHS Publication No. 166. 43-50.

Weisman, R. N. 1977. **Water Resources Research**. 13: 337-342.

Williams, L. D. 1988. Estimation of frequency of occurrence of dry snowcover in Germany. Final report to Royal Signals and Radar Establishment, St Andrew's Road. Malvern. Ministry of Defence agreement No. 2087/29.

7.6 Notation

C_n bulk heat transfer coefficient for neutral stability
c specific heat capacity of ice ($J\ kg^{-1}\ °K^{-1}$)
c_s specific heat capacity of dry snow ($J\ kg^{-1}\ °K^{-1}$)
c_p specific heat of air at constant pressure ($J\ kg^{-1}\ °K^{-1}$)
e_a vapour pressure of air (Pa) (Eq. 6)
e_s vapour pressure at the snow surface (Pa) (Eq. 17)
e_{sat} saturation vapour pressure over water (Pa) (Eq. 16)
F_h correction factor for departure from neutral stability in equation for estimating sensible heat flux Q_h
F_v correction factor for departure from neutral stability in equation for estimating latent heat flux Q_v
g acceleration of gravity ($m\ s^{-2}$)
G global short wave radiation (direct and diffuse) at the surface ($W\ m^{-2}$)
H station height above sea level (m)
h snow depth (m)
k Boltz'a constant in Eq. 5 (set to 0.2)
L latent heat of sublimation or vaporisation ($J\ kg^{-1}$)
L_f latent heat of fusion ($J\ kg^{-1}$)
M melt rate of snow ($kg\ m^{-2}\ s^{-1}$)
$LOSS$ Melt volume per hourly time step ($kg\ m^{-2}\ hr^{-1} = mm\ m^{-2}\ hr^{-1}$)
N cloud cover fraction
p air pressure (Pa)
p_o air pressure at sea level (Pa)
Q energy flux densities ($W\ m^{-2}$), including:
Q_s absorbed shortwave radiation (Eq. 2)
Q_a longwave radiation from the atmosphere (Eq. 4)
Q_e longwave radiation emitted by the snow surface (Eq. 8)
Q_h sensible heat transfer between air and snow surfaces (Eq. 9)
Q_v latent heat transfer between air and snow surfaces (Eq. 10)
ΣQ sum of energy flux densities for melting snow ($W\ m^{-2}$)
Ri bulk Richardson number
S relative heat storage of snow ($J\ m^{-2}$) (Eq. 19)
S_{max} maximum storage of liquid water in pores in snow $S_{max} = L_f W_c$
T_a air temperature (°K)
T_m melting temperature of ice (°K)
T_s snow surface temperature (°K)
T_i snow surface temperature at hour i (°K)
T_z snow temperature at height z (°K)
$\overline{T}$ mean snow temperature (°K)
T_o snow temperature at base of snow (°K)
t time (s)
Δt time step delta t (= 3600 sec)
u wind speed ($m\ s^{-1}$)
w liquid water content of snow at height z ($kg\ m^{-3}$)
W total liquid water content in the snow pack ($kg\ m^{-2}$)

W_c saturation value of W (kg m^{-2})
WE water equivalent of snow (kg m^{-3})
z height above ground (m)
z_u height of wind speed measurement (m)
z_o roughness length (m)
α albedo of snow (at current time step)
a_{max} maximum albedo if clean dry snow
a_g albedo of bare soil surface underlying snow
ε_a effective clear sky emmissivity of atmosphere (Eq 5)
ε_s emissivity of snow (taken as 0.97 ie near black body)
κ von Karman constant (in Eq. 11) (taken as 0.4)
ρ_a air density (kg m^{-3})
ρ_z snow density at height z (kg m^{-3})
$\overline{\rho}$ mean snow density (kg m^{-3})
σ Stefan-Boltzman constant (W $m^{-2}{}^\circ K^{-4}$)

7.7 SNOWMELT program listing

```
**************************************************************************
**
* PROCEDURE SNOWMELT  && Version 3.2  Last Revised: May 5, 1991
**************************************************************************
**
* Written by: R. Mac Millan
* Date: Dec 10, 1990
* Last Revision: May 9, 1991
* Acknowledgement: Algorithms were extracted from a program written by
* L. Williams (1988) with the approval & assistance of Dr. Williams
**************************************************************************
**
* DESCRIPTION:
* This program estimates the volume of meltwater released from a snow pack
* of depth H during a time interval DT where DT is usually 1 hour. Snowmelt
* occurs whenever the surface temperature of the snow is raised to 0 C
* The procedure estimates the temperature of the snow surface during each
* time step based on the temperature at the previous time step and the
* net energy flux from the last time step to the present time step. If
* energy is added to the snowpack, it is first used to raise the temp of
* the snow and overcome any negative (cold) energy storage. Once the snow
* has been warmed to 0 degrees it begins to melt. The snow can retain a
* percentage of liquid water in pores in the snow but once that maximum
* storage capacity is exceeded any further production of meltwater is
* released from the snow pack onto the soil surface.
**************************************************************************
**

SET TALK OFF
SET ECHO OFF
CLEAR SCREEN
* Declare all variables and initialize to zero (0)
ABO    = 0.0
ABOG   = 0.0
ABOMAX = 0.0
COFA   = 0.0
COFB   = 0.0
CS     = 0.0
CH     = 0.0
CL     = 0.0
CRI    = 0.0
C4T    = 0.0
DEPCLASS = 0
DES    = 0.0
DFH    = 0.0
DTS    = 0.0
DTM    = 0.0
DTL    = 0.0
DT2    = 0.0
DQ     = 0.0
EA     = 0.0
EG     = 0.0
```

```
EPA     = 0.0
ESB     = 0.0
ES      = 0.0
FH      = 0.0
FRI     = 0.0
H       = 0.0
HL      = 0.0
HS      = 0.0
LASTS   = 0.0
LOSS    = 0.0
MAXDEP  = 0.0
METEOFILE = " "
MELTFIELD = " "
Q       = 0.0
RA      = 0.0
RE      = 0.0
RHO     = 0.0
RHOA    = 0.0
RIC     = 0.0
RIN     = 0.0
RS      = 0.0
S       = 0.0
SMAX    = 0.0
SNOWDEPTH = 0.0
SNOWSURT = 0.0
STARTEMP = 0.0
TA      = 0.0
TD      = 0.0
TG      = 0.0
TS      = 0.0
TSB4    = -3.0 + 273.15
TS2     = 0.0
T2      = 0.0
T4      = 0.0
WCT     = 0.0
WCDT    = 0.0
WE      = 0.0
WLFMAX  = 0.0

SET DECIMAL TO 15   && essential to maximize precision of calculations

* RHO  = 230 && Read this from SETUP file so as to be able to change
* value easily without having to recompile program. Value should be
* given in SI units (ie 200- 300 Kg m-3) NOT cgs (ie .20 - .33 gm cm-3)
* Zebarth and De Jong (1989) report snow density relatively constant at
* 0.20 - 0.23 Mg m-3 (200-230) for spring snow in central Saskatchewan

* Larry Williams set up the following parameter values (not to change)
WLFMAX = 16700.0       && used to compute maximum water storage in snow
* WLFMAX is computed as 5% * LF where LF= 3.35*10^5. Max liquid water
REO = -306.15          && constant for RE = es*sigma*T4 when T=273.15
CS = 2100              && specific heat capacity dry snow J kg-1 K-1
LF = 3.34*10^(5)       && latent heat of fushion J kg -1 pg 316 Male/80
DT = 3600              && seconds in 1 hour time step (60*60)
EO = 610.64            && emperical constant for sat vap press over ice
```

```
T0 = 273.15            && temp in degress K at 0 degrees C
ESBS = 5.5 * 10^(-8)   && constant for RE from es=.97 * sigma = 5.67*10-8
FSB = 2.2*10^(-7)      && constant used in computing DQ in iteration
SBCONST = 5.67*10^(-8) && Stephan-Boltzman constant W m-2 K-4

* Constants and parameters for calculating 'bulk transfer coefficient'
RHOA = 1.225       && density of air (kg m-3)
CP  = 1005         && specific heat air @constant pressure (J K-1 kg-1)
L   = 2.835*10^6   && latent heat of vaporisation of water (J kg-1)
P   = 1.013*10^5   && air pressure taken as constant (Pa)

* CHP  = 1.9   then  CHC  = CHP*RHOA    && quick route to CHC
* CLP  = 1663  then  CLC  = CLP*RHOA/P  && quick route to CLC
* Computations for "Bulk Transfer Coefficient" with von Karman constant
K  = 0.4       && K is the von Karman constant
ZU = 1000.0    && ZU is the height of wind speed measurement (1000 cm)
ZO = 0.1       && ZO is an emperical roughness coefficient (can be changed)
CN = (K/LOG(ZU/ZO))**2   && CN is the "bulk transfer coefficient"

CHC = CN * RHOA * CP     && Parameter in bulk trans coefficient
* CHC should have a value of about 2.3275 (can "tweak" by changing ZO)
CLC = 0.5 * CN * (0.622 * RHOA * L / P)  && Parameter in bulk trans cof
* CLC should have a value of about 0.02 but can be "tweaked" by adjusting
* the constant 0.5 above or by altering CN by changing the value for ZO

* Set up time step increments
DT2 = 2.0 * DT
DTM = DT / (1.0* 10^(6))
DTL = DT / LF
* LF = 3.34e5 = latent heat of fushion allocated value above

frame = CHR(201) + CHR(205) + CHR(187) + CHR(186) + ;
     CHR(188) + CHR(205) + CHR(200) + CHR(186) + ;
     CHR(32)

STORE  1 to TOP
STORE  0 to LEFT
STORE 20 to BOTTOM
STORE 79 to RIGHT

@ TOP,LEFT,BOTTOM,RIGHT BOX FRAME
@ 2,4 SAY " Program Snowmelt: Computes hourly energy balance for Snowmelt"

SELECT A
USE SETUP
* NOTE: I will need to keep track of or input a value for TS[i] = the
* snow surface temperature at time step i (deg K). Just set for now!!!
* Suggestion is to estimate snow surface temperature as just 1 deg higher
* then air temperature at the initial starting day and time (at midnight
* when snow is warmer than air). It would be best to make it easy to vary
* this initial estimate therefore there should be a field in the SETUP file
* called TOPSNOWT in which to record the initial surface snow temperature
* There needs to be a second field in the SETUP file for recording the
* initial temperature of the snow at the soil-snow interface. I choose to
* set the starting snow/soil temperature BOTSOILT to equal the temperature
```

```
* at the snow/soil interface from soil temperature probes.

SNOWSURT = TOPSNOWT + T0  && Compute and record the initial snow surface T
IF SNOWSURT > T0  && Makes sure that starting surface temp is <= melting T
 SNOWSURT = T0
ENDIF
STARTEMP = (TOPSNOWT+BOTSNOWT)/2  && Computes average initial soil T
IF STARTEMP > 0.0  && Average snow temp must be greater than melting temp
 STARTEMP = 0.0
ENDIF

RHO     = SNOWDENS   && Read from SETUP file. Values in range 200-230
MAXDEP  = MAXSNOW    && Read from SETUP file. Number is depths to compute
METEOFILE = LTRIM(TRIM(METFILE)) && Ditto. Name of dBase met data file
ABOG     = ALBSOIL   && from .15 - .17 for bare soil (Marshall and Warren,1987)
ABOMAX   = ALBSNOW    && Max snow albedo .74-.80 from (Marshall and Warren,
                      && 1987)
cofA = 0.45  && value from Marshall and Warren (1987)
cofB = 2.25  && value from Marshall and Warren (1987)
* WE = RHO * H  && This is calculated below for each new H
* ABO = ABOMAX - ((ABOMAX - ABOG)/((cofA*WE+1)**cofB)) && calculated
below
* This equation was determined to be set up for WE expressed in cgs units
* As such the estimates are incorrect when RHO is expressed in kg m-3 and
* H in m (ie SI units). Since I can't change the emperical coefficients it
* is necessary to change WE into cgs units. This is done by multiplting by
* a factor of 0.1 (RHO gm cm-3 = RHO kg m-3 * 10-3) (H cm = h m * 100)
* The modified equation used here after is:
*     ABO = ABOMAX - ((ABOMAX - ABOG)/((cofA*(WE*0.1)+1)**cofB))
SELECT B
USE &METEOFILE ALIAS METDAT
****************************************************************
* Set up loop here to assign a value for depth of snow (H), compute
* the snow temperature and melt volume for all time steps up until all
* snow has melted for a given starting snow depth and store the value
* for meltvol into the correct field (ie MV5, MV10...MV200)
****************************************************************
* DEPCLASS = 1
* DO WHILE DEPCLASS < MAXDEP && Deleted just for now
DEPCLASS = 4  && Temporary insert to compute and store albedo by hour
DO WHILE DEPCLASS = 4  && Temporary insert to compute and store albedo
 DO CASE
  CASE DEPCLASS = 1
   MELTFIELD = "MV5"
   SNOWDEPTH = 0.05
  CASE DEPCLASS = 2
   MELTFIELD = "MV10"
   SNOWDEPTH = 0.10
  CASE DEPCLASS = 3
   MELTFIELD = "MV15"
   SNOWDEPTH = 0.15
  CASE DEPCLASS = 4
   MELTFIELD = "MV20"
   SNOWDEPTH = 0.20
  CASE DEPCLASS = 5
```

```
      MELTFIELD = "MV30"
      SNOWDEPTH = 0.30
    CASE DEPCLASS = 6
      MELTFIELD = "MV40"
      SNOWDEPTH = 0.40
    CASE DEPCLASS = 7
      MELTFIELD = "MV50"
      SNOWDEPTH = 0.50
    CASE DEPCLASS = 8
      MELTFIELD = "MV60"
      SNOWDEPTH = 0.60
    CASE DEPCLASS = 9
      MELTFIELD = "MV70"
      SNOWDEPTH = 0.70
    CASE DEPCLASS = 10
      MELTFIELD = "MV80"
      SNOWDEPTH = 0.80
    CASE DEPCLASS = 11
      MELTFIELD = "MV90"
      SNOWDEPTH = 0.90
    CASE DEPCLASS = 12
      MELTFIELD = "MV100"
      SNOWDEPTH = 1.00
    CASE DEPCLASS = 13
      MELTFIELD = "MV125"
      SNOWDEPTH = 1.25
    CASE DEPCLASS = 14
      MELTFIELD = "MV150"
      SNOWDEPTH = 1.50
    CASE DEPCLASS = 15
      MELTFIELD = "MV175"
      SNOWDEPTH = 1.75
    CASE DEPCLASS = 16
      MELTFIELD = "MV200"
      SNOWDEPTH = 2.00
    OTHERWISE
  ENDCASE
  DEPCLASS = DEPCLASS + 1
  STORE .F. TO FINISHED
  H = SNOWDEPTH
* NOTE: We need to set or read a sequence of values for snow depth H
*     The curent program assigns 16 arbitrary snow depths from 0.05 m
*     to 2.00 m to compute melt volumes from these starting depths
  @ 21, 4 SAY "Estimating snowmelt for initial snow depth of: "+STR(H,4,2)
  @ 17, 40 SAY "INITIAL SNOW DEPTH = "+STR(H,4,2)
* NEXT: We need to reset the snow surface temperature to the initial snow
*     surface temperature read from the SETUP file for the starting day.
  TS  = SNOWSURT
  IF TS < T0 - 1
    TSB4 = TS + 1     && Convenient to just set TSB4 to 1 deg warmer
  ELSE
    TSB4 = T0
  ENDIF
* NOTE: can use WE (water equivalent) to replace RHO(Density) * H(height)
*     in most of the equations. Values should be 220*H ie 11 to 440
```

```
 WE = RHO * H
 @ 17, 4  SAY "INITIAL WATER EQUIV = "+STR(WE,6,1)
 WCT  = WE * CS / DT2
* NOTE: Need to calculate WCT for each new H as Water Equivalent [WE] is
*     different for each value of H (starting depth of snow)
 ABO = ABOMAX - ((ABOMAX - ABOG)/((cofA*(WE*0.1)+1)**cofB))
 SMAX = WLFMAX * WE  && Maximum 'heat' stored as liquid water
 S = STARTEMP*WE*CS  && IMPT!! Sets the initial heat storage of snow pack
 LOSS = 0.0
 DO MELTSNOW
ENDDO
* END of program after 16 passes through the met file, one for each depth
@ 22, 4 SAY "Program completed!  Snowmelt computed for all depths"

************************************************************
PROCEDURE MELTSNOW
************************************************************
* This procedure computes an hourly energy balance for a snowpack of
* initial starting depth H and maintains a running total for the heat
* stored in a snowpack. When the surface temperature of the snowpack
* exceeds 0 deg C any additional energy input into the snow produces
* a volume of meltwater in proportion to the latent heat of melting
* of snow. This meltwater may refreeze if lower layers of the snowpack
* are still below freezing or, if the snow is isothermal it may fill
* voids in the snow until the maximum capacity of the snow to hold
* liquid water has been exceeded. After that point, all further melt
* water produced by positive energy input produces meltwater that is
* lost from the snowpack and is available for runoff in that time step.
* Scaling has been used to estimate likely meltwater volumes for a
* fixed and limited number of initial starting depths of snow for each
* hourly time step. Melt volumes for grid elements with initial snow
* depths different than any of the reference starting depths are estimated
* using a linear interpolation between the two reference depths that
* bracket the actual initial snow depth for that grid element.
*************************************************************

GO TOP              && Goes to the top of the met file
DO WHILE .NOT. EOF()  && Processes each hourly record sequentially
@4,4 SAY "Processing: Day No: "+STR(JULIAN,3,0)+" Hour: "+STR(HOUR,2,0)

TA = TEMP + T0        && converts degrees celcius to degrees Kelvin
* where: T0 = 273.15 ie. the melting temperature of ice in degrees K
T2 = TA * TA          && Square of temperature in degrees K
T4 = T2 * T2          && Forth power of temperature in degrees K
TG = TA - TS          && Difference in temp between air and snow surf
@5,4 SAY "INPUT DATA:"
@6,4 SAY "TA = "+STR(TA,5,1)+"   TS = "+STR(TS,5,1)+"  TG = "+STR(TG,5,1)
@7,4 SAY "RH = "+STR(RH,4,2)+"  WIND = "+STR(WIND,4,1)+"  RGLOB =
"+STR(RADIA,6,2)

UA = WIND             && Reads value of wind speed (m/s) from met file
CH = CHC * UA           && CH used in computation of Sensible heat flux
CL = CLC * UA          && CL used in calculation of Latent heat flux

C4T = 4.0 * TA
```

```
        IF UA <> 0.0
                FRI = 147.0 / (UA*UA) && F is for five as in 5Ri
* where 147.0 comes from 5*g*za where g=accel of gravity and
*     za=height at which temp is measured (assumed 1.5 m)
        ELSE
                FRI = 1470  && Produces large value when WIND = 0
        ENDIF
ESAT = 610.7*EXP(17.491*(TA-T0)/(TA-32.48))
EA = RH * ESAT

* NOTE: ESAT(n) is a user defined function that solves the following eqn
*     ESAT(n) = 610.7 * EXP(17.491 * (n - T0) / (n - 32.48))
* This eqn solves for the saturation vapour pressure over H2O (SI units)

EPA = 0.68 + (0.0036 * SQRT(EA))
* EPA is the atmospheric emmissivity Epsilon A. Larry had this data-I don't
* He suggests I use the Brunt formula given above to calculate EPA
* The coefficients for the formula come from work by Male and Granger(1979)
* at Bad Lake Saskatchewan a1=0.68, b1 = 0.0036 They may not reproduce
* diurnal variation well but are the best I have.
* NOTE: I changed b1 from .036 to .0036 to adjust for change to SI units

ESB = EPA * SBCONST

*   where: EPA is Epsilon A the effective clear sky emmissivity of atm
*          SBCONST is the Stephan-Boltzman Constant (5.67*10^(-8)

RA = (1 + 0.2 * CLOUD**2) * (ESB * T4)
RS  = (1.0 - ABO) * RADIA  && NOTE: RADIA is in W m-2 per day (24 hours)
* Need RS and RA to compute sum RIN = RS + RA (incoming short and long rad)

RIN = RS + RA

* Prepare for start of Newton-Raphson iteration here!!!
ITER = 1
TS2 = TS * TS

* START Newton-Raphson iteration here!!!

STORE .F. to FINISHED

DO WHILE .NOT. FINISHED && FINISHED is set to .T. when iteration converges
@ 4,45 SAY "Interation No: "+STR(ITER,2,0)

TG = TA - TS
* TS is snow surface temperature in deg K. TS is carried over from last
* time step to this time step as TS=TSB4
* TA is air temperature in deg K
* TG is the difference in temperature air to snow

IF TG = 0.0        && Stable conditions FH is unity (ie FH=1)
        FH  = 1
        DFH = 0.0
ELSE
        CRI = FRI * TG / (TA + TS)
```

```
        IF CRI > 0.0
                IF CRI > 1
                        FH  = 0.0
                        DFH = 0.0
                ELSE
                        RIC = 1.0 - CRI
                        FH  = RIC * RIC
                        DFH = C4T * CRI * RIC / (T2 - TS2)
                ENDIF
        ELSE
                FH  = SQRT(1.0 - 8.0 * CRI)
                FH  = SQRT(FH)
                DFH = C4T * CRI / (FH*FH*FH*(T2-TS2))
        ENDIF
ENDIF
HS = FH*CH*TG    && Compute Qh=HS the sensible heat flux here
* END OF STEP 1
IF ITER <> 0
        * DO STEP 2
        TD   = TS - 0.56
        ES   = EO*EXP(22.457*(TS-T0)/TD)
        DES  = 6121.55 * ES / (TD*TD)
        EG   = EA - ES
        RE   = -ESBS*TS2*TS2      && Emitted long wave radiation (Qe)
        HL   = FH * CL * EG       && Latent heat transfer (Qv)
        WCDT = WCT * (TS - TSB4)  && Change in liquid water content
        Q    = RIN + RE + HS + HL - WCDT
        DQ   = -FSB*TS2*TS+CH*(TG*DFH-FH)+CL*(EG*DFH-FH*DES)-WCT
        DTS  = Q / DQ             && change snow surf temp in this iter
        TS   = TS - DTS           && new snow surface temp for next iter
        IF ABS(DTS) > 0.01
                ITER = ITER + 1
                IF ITER > 30
                        IF TS > T0
                                TS=T0
                                ITER = 0
                        ELSE
@ 21,4 SAY "Failed to converge after 20 iterations at Day No: " + STR(JULIAN,3,0)+"
Hour: " + STR(HOUR,2,0)
                                STORE .T. TO FINISHED
                                GO BOTTOM
* LARRY ADVISES STOPPING THE PROGRAM IF CONVERGENCE DOESN'T
* OCCUR AFTER 20 ITERATIONS FOR ANY GIVEN DAY/HOUR
* COMBINATION... CHECK DATA!!!!
                        ENDIF
                ELSE
                        TS2 = TS*TS
                ENDIF
        ELSE
                IF TS >= T0
                        TS = T0
                        ITER=0
                ELSE
                        STORE .T. TO FINISHED
                ENDIF
```

```
        ENDIF
ELSE   && IE IF ITER=0 (has to be set to 0 in program above)
        RE=REO              && Qe = emitted longwave radiation
        HL=0.882*FH*CL*(EA-EO)  && Qv = latent heat transfer
        Q=RIN+RE+HS+HL        && Q = sum of all energy terms
        STORE .T. TO FINISHED
ENDIF

ENDDO

* PUT STEP 5 IN HERE
IF TS < T0              && If snow surface temp is below melting T
        S = S + WCDT * DT   && New value for 'heat storage' of snowpack
        LOSS = 0.0 && ie no loss of water can occur if surface snow < 0
* This 'adds heat or cold' to the heat storage term whenever the computed
* value for the new snow surface temperature [TS] is < 0.
ELSE  && ie if TS > 0 then the snow surface > 0 and is melting
        S = S + Q * DT
* This adds (Q*DT) heat to the heat storage term whenever the computed
* value for the new snow surface temperature [TS] is > 0 (ie melting).
        IF S > SMAX  && if the amount of heat stored exceeds Smax
                IF WE > 0  && if there is any snow left (ie WE > 0)
                        LOSS = (S - SMAX) / LF && amount H2O released
                        IF LOSS < WE
                                WE   = WE - LOSS && snow water eqiv reduced
                        ELSE
                                LOSS = WE  && all remaining snow water lost
                                WE = 0.0
                        ENDIF
                        WCT  = WE * CS / DT2
                        WCDT = 0.0
                        SMAX = WLFMAX * WE
                        S    = SMAX
* NOTE: remember to add formula to calculate new albedo with new we value
                        ABO=ABOMAX-((ABOMAX-ABOG)/
                        ((cofA*(WE*.1)+1)**cofB))
                ELSE
                        STORE .T. TO FINISHED
                        LOSS = 0.0
                        ABO = ABOMAX-(ABOMAX-ABOG)
                        @ 22, 4 SAY "LOSS IS 0.0 FOR REMAINING HOURS"
                        DO WHILE .NOT. EOF()
                         REPLACE &MELTFIELD WITH LOSS
                         SKIP
                        ENDDO
                ENDIF
        ELSE
                LOSS = 0.0
        ENDIF
ENDIF
LASTS = TSB4
TSB4 = TS
* TSB4 should be used as the value for Ti[n-1] in the next iteration

@  8, 4  SAY "OUTPUT DATA:"
```

```
@ 8, 40 SAY "ABS(DTS)= "+STR(ABS(DTS),6,2)
@ 10, 4  SAY "RA  = "+STR(RA,6,1)
@ 10, 40 SAY "RE  = "+STR(RE,6,1)
@ 11, 4  SAY "RS  = "+STR(RS,6,1)
@ 11, 40 SAY "HS  = "+STR(HS,6,1)
@ 12, 4  SAY "RIN = "+STR(RIN,6,1)
@ 12, 40 SAY "HL  = "+STR(HL,6,1)
@ 13, 4  SAY "Q = RIN+RE+HS+HL is: "+STR(Q,6,1)
@ 14, 4  SAY "TS  = "+STR(TS,6,1)
@ 14, 40 SAY "WCDT = "+STR(WCDT,6,1)
@ 15, 4  SAY "TSB4 = "+STR(LASTS,6,1)
@ 15, 40 SAY "WCT  = "+STR(WCT,6,1)
@ 16, 4  SAY "S    = "+STR(S,10,1)
@ 16, 40 SAY "SMAX = "+STR(SMAX,10,1)
@ 18, 4  SAY "PRESENT WATER EQUIV = "+STR(WE,6,1)
@ 18, 40 SAY "PRESENT SNOW DEPTH = "+STR((WE/RHO),4,2)
@ 19, 20 SAY "Melting this hour = "+STR(LOSS,6,1)
IF LOSS > 0.0
 REPLACE &MELTFIELD with LOSS
 REPLACE SMELT WITH .T.
ELSE
 REPLACE &MELTFIELD WITH 0.0
ENDIF
IF DEPCLASS = 5
 REPLACE QS with RS
 REPLACE QA with RA
 REPLACE QE with RE
 REPLACE QH with HS
 REPLACE QV with HL
 REPLACE SUMAE with RA+RE
 REPLACE DELTAG with WCDT
 REPLACE SNOWT with TS
 REPLACE WATEQV with WE
 REPLACE SNOWDEP WITH WE/RHO
 REPLACE ALBEDO WITH ABO
ENDIF
SKIP
ENDDO
* END of DO WHILE .NOT. EOF() do loop for passes through the met file
@ 22, 0   && This clears the screen at line 22 for start of next pass
****************************************************************
```

APPENDIX 8

THE POTENTIAL EVAPORATION SUB-MODEL

8.1 Introduction

This appendix details the logic and the mathematical equations used to predict potential evaporation at the study site for each hourly time step. All of the equations (Table A8.1) are based on widely accepted, previously reported formula as implemented in the model SWATRE (Belmans et al. 1983). Data input requirements for the different equations vary, ranging in complexity from only temperature and radiation data to temperature, wind speed, humidity, cloud cover and radiation. The equations using all possible parameters are usually considered the most responsive to climatic variations (Warnaka and Pochop, 1988).

The mathematical formula, underlying assumptions and input requirements associated with each equation are discussed in greater detail below. A complete listing of the computer code used to implement the equations follows the discussion.

Table A8.1 Evaporation equations extracted from the SWATRE model for use in DISTHMOD and their corresponding data requirements and source references

Method and Reference	Temp	Relative Humidity	Wind Speed	Global/Net Radiation	Cloud Cover	Leaf Area Index
Penman (1948)	Yes	Yes	Yes	Yes	Yes	
Monteith/Rijtema (1965)	Yes	Yes	Yes	Yes		Yes
Priestly-Taylor (1972)	Yes			Yes		
Ritchie (1972)	Yes			Yes		Yes
Makkink (no ref)	Yes			Yes		

8.2 General background on evapotranspiration

The following general discussion of the basic principals underlying the formulation of mathematical equations for evapo-transpiration is extracted largely intact from Lockwood (1985). It is intended to provide the theoretical framework required to properly understand the evaporation equations used in the present research.

Lockwood (1985) describes evapo-transpiration as involving three simultaneous dynamic processes (King, 1961), namely;

a) the flow of water vapour by turbulent and molecular diffusion from the evaporating surface to the atmosphere
b) the flow of heat by radiation, convection and conduction to the evaporating surface and the removal therefrom as latent heat of vaporization; and
c) the flow of water through the soil and plants to the evaporating surface.

Investigations of the mechanics of each of these three processes have resulted in the following equations describing their controlling factors.

Turbulent transfer requires that water vapour from an evaporating surface must first pass through a thin laminar layer next to the surface where only molecular diffusion may take place. Once through this layer it is then transported upwards by turbulent motions. The basic equation for the mean vertical transfer of water vapour is (Lockwood, 1985);

$$E = -\rho K_v \frac{\partial q}{\partial z} \qquad \textbf{(A8.1)}$$

where:

K_v = eddy velocity of water vapour
q = specific humidity (mass of moisture per unit mass of moist air)
ρ = air density

According to Thornthwaite and Holtzman (1939), evapotranspiration can be calculated using the following propositions:

1) the transfer factor for momentum is identical with that for water vapour (i.e. $K_M = K_v$)
2) the shearing stress is constant with height
3) the wind velocity u_z at the height z may be expressed by a logarithmic wind function.

These propositions lead, in a neutral environment, to the following equation for evapo-transpiration (E_t).

$$E_t = \frac{\rho k^2 (u_2 - u_1)(q_1 - q_2)}{\left[Ln \frac{(z_2 + z_0 - d)}{(z_1 + z_0 - d)} \right]^2} \quad \textbf{(A8.2)}$$

This last equation is similar to the empirical Dalton equation (Lockwood, 1985) which relates evapo-transpiration to the prevailing wind velocity and the vapour pressure gradient or degree of atmospheric saturation (e_s - e_a). The Dalton equation is:

$$E_t = f(\overline{u})(e_s - e_a) \quad \textbf{(A8.3)}$$

where $f(\overline{u})$ is an empirically derived function of the wind velocity, usually given in the form :

$$f(\overline{u}) = a(1 + b\overline{u}) \quad \textbf{(A8.4)}$$

where $\overline{u}$ is the time averaged wind velocity measured at a standard height and a and b are constants. This empirical approach to estimating the turbulent transfer component of evapo-transpiration is incorporated in both the Penman and the Monteith-Rijtema equations for evapo-transpiration discussed below.

The second of King's three dynamic processes (see Lockwood, 1985 p 170) recognizes that evapo-transpiration requires a supply of energy to be used as latent heat of vaporization. Neglecting the amount of energy used for photosynthesis and the supply of advective energy, the energy balance can be written as follows:

$$R_N = (1 - \alpha)R_s - R_{NL} = LE_t + C + S + G \quad \textbf{(A8.5)}$$

where R_N is the net radiation, α is the albedo of the surface, R_S is the global short wave radiation, R_{NL} is the net long wave radiation, L is the latent heat of vaporization, E_t is the evapo-transpiration, C is the sensible heat transfer to the atmosphere, S is the sensible heat transfer to the soil and G is the storage of heat in the crop.

The main difficulty in using the energy balance approach arises from the distribution of energy between latent heat and sensible heat transfer to the atmosphere. The ratio of the sensible heat flow to the latent heat flow is know as the Bowen ratio Beta (ß) and is written as:

$$\beta = \frac{C}{LE_t} = \gamma\left(\frac{K_H}{K_v}\right)\left(\frac{T_s - T_a}{e_s - e_a}\right) \quad \textbf{(A8.6)}$$

where gamma (γ) is the psychrometer constant (about 0.65), K_H is the eddy conductivity, T_s and T_a are respectively the surface and air temperature, and e_s and e_a are the vapour pressure respectively at the surface and in the air. With the Bowen ratio, the expression for the energy used for evaporation becomes:

$$LE_t = \frac{R_N - S}{1 + \beta} \quad \textbf{(A8.7)}$$

8.3 The Penman equation

The Penman equation combines consideration of both the aerodynamic and energy balance elements of evaporation discussed above. It uses standard meteorological data, specifically; temperature, relative humidity, net radiation, wind speed and cloud cover. It neglects the storage of heat in the soil and assumes a saturated vapour pressure at the surface (see Lockwood, 1985 page 171).

The original formulation of the Penman equation is written as:

$$E_t = \frac{\Delta R_N / L + \gamma E_a}{\Delta + \gamma} \quad \textbf{(A8.8)}$$

where delta (Δ) is the slope of the temperature - vapour pressure curve at air temperature T and E_a (aerodynamic evaporation) is calculated from an aerodynamic relationship in the form:

$$E_a = (e_s - e_a)(f(\bar{u})) \quad \textbf{(A8.9)}$$

A variety of forms of this equation exist in which the value of the constants depends on the nature of the surface. The particular formulation adopted by Penman (1956) is:

$$E_a = 0.165(V_s - V_a)(0.8 + u_2 / 100) \quad \textbf{(A8.10)}$$

in which E_a is in mm day^{-1}, V_s and V_a are respectively the saturated and actual vapour pressures at the screen level in mbar and u_2 is wind speed at a height of 2 m in km day^{-1}.

It is instructive to compare the implementation of this equation in the SWATRE model with the formal equation developed above. The SWATRE equation is:

$$eopen = \frac{convert*(slope*rnet) + (\lambda*28.368*0.26)(0.54*wind + 0.5)(vpd)}{(slope+\gamma)} \quad \textbf{(A8.11)}$$

in which convert is used to change the units in which eopen is reported from W m^{-2} to mm day^{-1}. The expression for convert is:

$$convert = \frac{60*60*24 \text{ sec day}^{-1}}{2.541*10^{-6} \text{ J kg}^{-1}} = 0.0352 \text{ kg m}^{-2} \text{ day}^{-1} \quad \textbf{(A8.12)}$$

in which 2.541 * 10^6 is L the latent heat of vaporization and the product of the numbers in the numerator is the number of seconds in a day (86400).

In the Penman equation, the left hand term in the numerator ($\Delta * R_N/L$) represents evaporation arising from radiative input and the right hand term ($\gamma * E_a$) represents aerodynamic evaporation. Both left and right hand terms are divided by the denominator ($\Delta + \gamma$).

The left hand side of the equation is easily identified in the SWATRE implementation where:

$$\Delta * R_N / L = slope*rnet*convert \quad \textbf{(A8.12)}$$

slope is the equivalent of delta (Δ) and represents the slope of the temperature-vapour pressure curve at air temperature T. It is computed empirically in SWATRE solely as a function of air temperature according to the following equations:

$$temk = temp + 273.15 \qquad \text{(converts celcius into kelvin)} \quad \textbf{(A8.13)}$$

$$wed = (0.0583*temk) - 2.1938 \quad \textbf{(A8.14)}$$

$$satvap = 1.332^{\frac{(1.08872*temk-276.4484)}{wed}} \quad \textbf{(A8.15)}$$

$$slope = \frac{13.7315 * satvap}{wed^2} \quad \textbf{(A8.16)}$$

The original Penman (1948) equation for estimating net radiation is given in Lockwood (1985) as:

$$R_N = R_{ss}(1-\alpha)(a+bn/N) - \sigma T^4\left(0.56 - 0.08\sqrt{V_a}\right)(0.1+0.9n/N) \quad \textbf{(A8.17)}$$

The SWATRE implementation of the above equation is:

$$rnet = \left(rglob*(1-0.06) - 5.67*10^{-8}*temk^4*\left(0.47 - 0.067*\sqrt{(satvap*rh)}\right)\right) \quad \textbf{(A8.18)}$$

The net radiation equation as implemented in SWATRE differs slightly from the original Penman equation. Differences in the value of coefficients arise mostly because the original Penman equation was expressed in cgs units (ie gm cal cm $^{-2}$) while the SWATRE equation uses SI units (ie W m^{-2}). A detailed comparison of the two equations helps to identify and explain the apparent differences.

The initial portion of both equations (up to, but not including -s or -5.67) is concerned with estimating the net flux of shortwave radiation. In the Penman equation, the total potential short wave radiation (R_{SS}) is reduced by assigning some loss to reflection as a function of albedo (a). The SWATRE implementation of the same equation uses a constant value of 0.06 for albedo. The constant value of 0.06 has been replaced in the present model with a variable a = albedo which may range from 0.95 for clean dry snow to 0.08 for wet black soils. A prescribed value for albedo is entered into the meteorological data set for each time step for the present exercise.

A second difference apparent between the two implementations of the Penman equation concerns the value on which the net shortwave radiation calculation is based. The SWATRE equation defines the input shortwave radiation in terms of global radiation (*rglob*) while the original Penman equation uses an equation. The result is that, when comparing:

$$rglob = R_{ss}*(a+b*n/N) \quad \textbf{(A8.19)}$$

The SWATRE equation is intended to utilise actual measurements of global short wave radiation taken in the field (*rglob*) whereas the original Penman equation uses as input

R_{SS}, the theoretical value for maximum solar radiation incident on a horizontal surface in the absence of the earth's atmosphere.This theoretical maximum is reduced according to an empirical equation which attempts to account for the amount of radiation intercepted or reflected away from the earth during the passage of shortwave radiation through the atmosphere. The ratio *n/N* relates the actual amount of bright sunshine (*n*) received at a site to the total possible amount of bright sunshine (*N*) in hours. The constants *a* and *b* are not universal, but vary from region to region because of changes in cloud structure and atmospheric interference. A table of suggested values is given in Lockwood (1985, p. 172). Alternately, *b* may be taken as constant at 0.54 and *a* may be calculated according to Glover and McCulloch (1958) as:

$$a = 0.29\cos(\phi) \quad \text{where } \phi = \textit{latitude} \qquad \textbf{(A8.20)}$$

These values of *a* and *b* will produce estimates for global radiation in cgs units of cal cm^{-2}.

The second portion of the two implementations of the net radiation equation (starting at -s or -5.67) is concerned with estimating the net longwave radiation affecting the surface. In this we wish to compare the original Penman formulation:

$$R_{NL} = -\sigma T^4\left(0.56 - 0.08\sqrt{V_a}\right)(0.1 + 0.9n/N) \qquad \textbf{(A8.21)}$$

with the equivalent implementation in SWATRE:

$$R_{NL} = -5.67e - 8*\left(temk^4\right)*\left(0.47 - 0.067*\sqrt{(satvap*rh)}\right)(1 - 0.8*\deg cld) \qquad \textbf{(A8.22)}$$

Working through the two equations from left to right sigma (s) is set to the constant value of 5.67 * 10^{-8} in the SWATRE equation and T^4 is the same as ($temk^4$). The actual vapour pressure at screen level (V_a) is computed in the SWATRE implementation as (*satvap*rh*) and is equivalent. The coefficients used in the SWATRE equation (0.47 and 0.067) differ from those given for the original Penman formulation (0.56 and 0.08). It is clear that these coefficients have been adjusted in the SWATRE implementation to reflect local conditions.

The final term in both equations is concerned with quantifying the effect of cloud cover on the net longwave radiation. In the original Penman equation, this is reported as the fraction of the day for which there has been bright sunshine. The cloud cover fraction (deg*cld*) used in the SWATRE equation may be viewed as the reciprocal of sunshine ratio (n/N). In both cases, continuous sunshine is equivalent to zero cloud cover and both equations estimate a maximum value for net longwave radiation away from the surface. This value is subtracted from the incoming shortwave radiation to yield an estimate of net radiation. In the case of continuous cloud cover, the sunshine ratio is zero, the cloud fraction is 1 and losses through emission of long wave radiation are minimised in both equations. The minimum value computed in the SWATRE implementation is 20% of the potential long wave radiation while in the original Penman formulation it is 10%.

The equations for net longwave radiation detailed above represent a summation of the individual equations for incoming longwave radiation from the atmosphere (Q_a) and outgoing longwave radiation emitted from the surface (Q_e) according to:

$$Q_e = -\sigma T^4 \varepsilon_s \qquad \textbf{(A8.23)}$$

$$Q_a = \sigma T \varepsilon_a \left(1 + N^2\right) \qquad \textbf{(A8.24)}$$

where sigma (s) is the Stafan-Boltzman constant, T_s and T_a are the temperatures of the surface and air respectively, ε_s and ε_a are the emissivity of the surface and the effective clear sky emissivity of the atmosphere respectively and N is the cloud cover fraction. The equation for net longwave radiation bears a strong similarity to the Brunt (1941) equation for estimating incoming atmospheric longwave radiation given in Lockwood (1985) as:

$$R_L = \sigma T^4 \left(0.52 + 0.065\sqrt{e}\right) \qquad \textbf{(A8.25)}$$

The composite equation (A8.22) represents a balance of the incoming longwave radiation equation according to the Brunt (1941) equation and the emitted longwave radiation according to equation (A8.25).

The two versions of the net radiation equation detailed above use slightly different values for the coefficients in the portion of the equation concerned with the estimation of net longwave radiation (R_{NL}). The SWATRE documentation provides no explanation for the choice of values for these coefficients but they are accepted for use in the present model since the SWATRE equation was developed for use at latitudes similar to those of the study area. It is evident that the coefficients could be allowed to vary between 0.52 and 0.56 for the first coefficient and 0.067 and 0.08 for the second.

Returning to consideration of the basic Penman equation, the numerator on the right hand side of the equation is concerned with estimation of evapo-transpiration arising from aerodynamic forces. In the original Penman equation it is ($\gamma * E_a$) where;

$$E_a = 0.165(v_s - v_a)(0.8 + u_2 / 100) \quad \textbf{(A8.26)}$$

in which E_a is in mm day^{-1}, v_s and v_a are respectively the saturated and actual vapour pressures at the level of the screen in mbar and u_2 is the wind speed at a height of 2 m in km day^{-1}. In the SWATRE model, the equivalent portion of the equation is;

$$\gamma * 28.368 * 0.26 * (0.54 * wind + 0.5) * vpd \quad \textbf{(A8.27)}$$

There are apparent differences in coefficients used in these two implementations of the same equation. The differences appear to be only partially explained by a dimensional analysis to convert the equations to the same units.

The psychometric constant (γ) is common to both implementations and can be dropped from consideration. The vapour pressure deficit (*vpd*) used in SWATRE is equivalent to (v_s - v_a) in the original Penman equation and so may also be dropped from consideration. It is worth explaining here that *vpd* is computed in SWATRE using the empirically estimated value for saturated vapour pressure (*satvap*) and an actual input value for relative humidity (*rh*) according to:

$$vpd = (1 - rh) * satvap \quad \textbf{(A8.28)}$$

This leaves the following non-corresponding portions of the equations to compare.

$$0.165(0.8 + u_2 / 100) = 28.368 * 0.26 * (0.54 * wind + 0.5) \quad \textbf{(A8.29)}$$

The left hand portion of the above equation reports results in mm day $^{-1}$ while the right hand portion works in W m^2. It is likely that the value 28.368 has been inserted into the SWATRE equation to convert from mm to W m^{-2}. This is apparent if we realise that 28.386 * 0.0352 = .9985 or approximately unity (1). If the value 28.386 is removed from the SWATRE implementation it will leave the two equations expressed in the same units of mm day^{-1}.

The expression for wind in the Penman equation uses $u_2/100$ in units of km/day but if we convert km/day to m/sec the conversion factor is (1000/86400 = 0.01157). This is approximately 1/100 so we may assume that the 100 in the Penman equation is used to convert km/day into m/sec wind speed. If this is so, then $u2/100$ is equivalent to wind in the SWATRE formulation. We may now compare the two expressions as:

$$0.165*(wind + 0.8) = 0.26*(0.54*wind + 0.5) \qquad \textbf{(A8.30)}$$

or, multiplying out;

$$0.165*wind + 0.132 = 0.1404*wind + 0.130 \qquad \textbf{(A8.31)}$$

These formulations can be seen to be virtually equivalent with most of the differences arising from conversion and rounding errors but with a residual difference apparently due to the selection by the SWATRE implementation of a coefficient of 0.1404 in place of the coefficient of 0.165 suggested in the original Penman equation.

The SWATRE implementation of the Penman equation obviously includes some locally calibrated coefficients and constants. These have been examined and explained as well as possible in the above paragraphs.

The Monteith - Rijtema Equation

The theoretical formulation of the Penman-Monteith equation is given in Lockwood (1985) as:

$$L_E = \frac{\Delta R_N - \frac{\rho C_p}{r_A}(e_s(T) - e)}{\Delta + \gamma(1 + r_s / r_A)} \qquad \textbf{(A8.32)}$$

where:

L_E is the latent heat of evaporation
Δ is the slope of the saturated vapour pressure curve
R_N is the net radiation
ρ is the density of moist air
C_p the specific heat of air at constant pressure

r_S surface resistance for the whole crop canopy

r_A is the combined "aerodynamic" resistance incorporating both the 'boundary layer' and the 'eddy diffusive' resistances

e_S stomatal vapour pressure (at temperature T)

e relative humidity at a source height above vegetation

γ the psychometric constant

The SWATRE model (Wesseling et al., (1989) implements the equivalent Monteith-Rijtema (1965) equation in four steps.

In the first step, the aerodynamic resistance r_a is estimated as a function of wind speed and degree of crop development as measured by crop height according to:

$$r_a = \frac{6.43*10^{-6}}{funcch*wind^{0.75}} \tag{A8.33}$$

The value for *funcch* is computed as a function of crop height using empirical coefficients appropriate for the crop at the site. For the present research, the expected condition is bare soil and no active crop growth. Consequently the value for *funcch* is here set permanently to the minimum value of $0.18*10^{-7}$ as implemented in the SWATRE model.

In the second step, the SWATRE model computes an intermediate variable called *ewet* according to:

$$ewet = \frac{0.00352*slope*rnet + 1210.0 / (r_a + vpd)}{(slope + \gamma)} \tag{A8.34}$$

This intermediate equation obviously corresponds to equation (A8.33) except for missing the term $(1 + r_S/r_A)$ containing the expression for surface resistance (R_S) which has yet to be calculated. In this equation, the value for the product ρC_p is set to a constant of 1210.0 and the variable *vpd* is a pre-computed value for vapour pressure deficit according to (A8.29) the formula *vpd*=(1.0-*rh*)**satvap*.

The value of the intermediate term *ewet* is used in the estimation of the value for the surface resistance r_S.The surface resistance is allowed to vary between a prescribed minimum (*rsmin*) and maximum (*rsmax*) value according to the formula:

$$rs = 10^{\frac{\log(rs\min)+(ewet-ewetlo)}{(ewethi-ewetlo)*\log(rs\max)-\log(rs\min)}} \qquad \textbf{(A8.35)}$$

Wesseling et al. (1989) recommend values of 33.0 for *rsmin* and 150.0 for *rsmax* for a potato crop. Lockwood (1985 p. 179) provides a table of typical crop surface resistance values indicating a low of 40 for alfalfa and a high of 400 for tundra. The surface resistance for a temperate grassland is given as 100 (s m^{-1}). In the SWATRE model, *rs* is set to *rsmin* whenever *ewet* is less than 0.7 and is set to *rsmax* whenever *ewet* is greater than 1.1. In the present implementation, *rsmin* and *rsmax* are read from the SETUP file and may be set to any appropriate value. Since there is no active vegetative cover during the periods of interest to this study, the values have no physical significance and have generally been left as recommended by Wesseling et al. (1989).

The final step in the SWATRE solution of the Penman-Monteith equation involves bringing together the previously computed portions of the equation to complete the solution for potential evapo-transpiration (*atmpot*) according to:

$$atmpot = \frac{slope + \gamma}{slope + \gamma(1 + r_s / r_a)} * (ewet - \text{int}\,cep) \qquad \textbf{(A8.36)}$$

The term *intcep* in this equation refers to water intercepted by vegetation and not involved in transpiration. It is set to zero for the present research since there is no active vegetation and therefore no iterception store.

The SWATRE implementation of the Penman-Monteith equation for evapo-transpiration was included in the present model so that, in the future, the model might be applied during periods of active vegetative growth of a crop cover. The values of potential evapo-transpiration predicted for the study site for the periods of interest were computed using the Penman-Monteith equation despite the fact that there was no active crop cover during those time periods. The equation gave reasonable values for potential evapo-transpiration none-the-less indicating that it could be applied to areas of bare soil during the non-growing period of early spring.

The Priestley-Taylor equation

The Priestley-Taylor equation is a simplification of the Penman equation to permit estimation of potential evaporation using only temperature and net radiation data. In it, the aerodynamic component of evapo-transpiration in the Penman equation is replaced by an empirical constant alpha which is adjusted according to the value (Δ) for the slope of the vapour pressure-temperature graph.

The Priestly-Taylor equation as implemented in SWATRE is:

$$atmpot = \frac{0.00352 * rnet * \alpha * slope}{slope + \gamma} \qquad \textbf{(A8.37)}$$

The conversion factor 0.00352 includes the latent heat of fusion and converts the result from W m^{-2} to cm day^{-1}. For the present implementation, the conversion factor is multiplied by 10 and divided by 24 to report results in mm hr^{-1}.

The empirical constant alpha is read from the SETUP file and is arbitrarily set to 1.35 as suggested by Wesseling et al. (1989). It may be adjusted within the range 1.25 to 1.45 as further suggested by Wesseling et al. (1989).

The value for net radiation may be computed as in equation (A8.23) above or, if only temperature and global radiation data is available, may be computed according to:

$$rnet = cofnga * rglob + cofngb \qquad \textbf{(A8.38)}$$

where *cofnga* and *cofngb* are empirical coefficients used for converting global radiation into net radiation. The coefficients are crop specific and reflect the influence of crop cover on both albedo and aerodynamic resistance. Wesseling et al. (1989) suggest values of *cofnga* = 0.54 and *cofngb* = -4.0 for use with a cover of potatoes. Since no coefficients are given for bare soil and since the area of interest had no active crop cover during the period of interest, the alternative Penman equation for estimating net radiation was used here in all cases.

Makkink equation

The SWATRE model includes an equation attributed to Makkink (reference not provided) that is very similar to the previously described Priestly-Taylor equation. It is given as:

$$emak = \frac{0.00352 * 0.65 * rglob * slope}{slope + \gamma} \qquad \textbf{(A8.39)}$$

This equation uses global radiation as input directly and reduces it by a constant factor of 0.65. It then multiplies the result by slope (Δ) as in the Priestly-Taylor equation, presumably to reflect the influence of aerodynamic factors. The ability to select the Makkink equation was included in the present model in order to permit estimation of potential evapo-transpiration with only the most restricted amount of meteorological input data (ie global radiation and temperature).

Ritchie equation

The SWATRE model also includes an equation for soil evaporation attributed to Ritchie (1972). This equation was included in the present model in order to permit comparison of estimates of potential evapo-transpiration made for the study site using the above equations with estimates for soil evaporation only made using the Ritchie equation. The Ritchie equation is given as:

$$atmeva = 0.00352 * \frac{slope}{slope + \gamma} * rnet^{-0.39 * lai} \qquad \textbf{(A8.40)}$$

in which *lai* is the leaf area index of the vegetation at the site and the other terms are as previously defined. The leaf area index may be taken as zero (0) for the study site during the periods of interest since there is no active crop growth in the early spring. In such circumstances, the Ritchie equation closely resembles the Priestly-Taylor equation with the parameter alpha set to one (1).

References

Belmans C., J. G. Wesseling and R. A. Feddes. 1983. Simulation model of the water balance of a cropped soil: SWATRE. **Journal of Hydrology.** 63: 271-286.

Brunt. D. 1941. Physical and dynamical meteorology. London. Cambridge University Press.

Glover. J. and J. S. G. McCulloch. 1958. The empirical relation between solar radiation and hours of sunshine. **Quarterly Journal of the Royal Meteorological Society.** 96: 172-175.

King. K. M. 1961. Evaporation from land surfaces. ***In:*** Proceedings of Hydrology Symposium No. 2: Evaporation. Ottawa. National Research Council of Canada. 55-82.

Lockwood. J. G. 1985. World climatic systems. Edward Arnold. London. pp. 153-188

Monteith, J. L. 1965. Evaporation and the environment. ***In:*** The state and movement of water in living organisms. Proc. 15th Symposium Society for Experimental Biology, Swansea. Cambridge University Press, London, pp. 205-234.

Penman. H. L. 1948. Natural evaporation from open water, bare soil and grass. Proc. Royal Society London. Ser A. 193: 120-145.

Penman. H. L. 1956. Evaporation: An introductory survey. **Netherlands Journal of Agricultural Science.** 4: 9-29.

Priestly. C. H. B. and R. J. Taylor. 1972. On the assessment of surface flux and evaporation using large-scale parameters. **Monthly Weather Review.** 100: 81-92.

Rijtema, P. E. 1965. An analysis of actual evapotranspiration. Agr. Res. Rep. 659. PUDOC. Centre for Agricultural Publications and Documentation, Wageningen, the Netherlands. 107 pp.

Rijtema. P. E. 1968. Derived meteorological data: transpiration. ***In:*** Agroclimatological methods: Proceedings of Reading Symposium. Paris. UNESCO. 55-72.

Ritchie, J. T. 1972. Model for predicting evaporation from row crops with incomplete coverage. **Water Resources Research.** 8: 1204-1213.

Thornthwaite. C. W. and B. Holtzmann. 1939. The determination of evaporation from land and water surfaces. **Monthly Weather Review.** 67: 1-8.

Warnaka. K. and L. Pochop. 1988. Analysis of equations for free water evaporation estimates. **Water Resources Research.** 24: 979-984.

Wesseling, J. G., P. Kabat, B. J. van den Broek and R. A. Feddes. 1989. SWACROP: Instructions for input. The Winand Staring Centre for Integrated Land, Soil and Water Research (SC). formerly Institute for Land and Water Management Research. P. O. Box 35. 6700 AA Wageningen. The Netherlands. 28 pp.

8.8 POTEVAP program listing

```
*****************************************************************
* Name:     Potevap.prg
* Author:   R. Mac Millan
* Credit:   Copied from program SWACROP Wesseling et al., 1989)
* Date:     Nov 26, 1990
* Version:  1.0
* Compile:  Clipper Potevap
* Link:     Plink Potevap C:\CLIPPER\CLIPPER,CLIPPER.ext;
* Note:     This procedure calculates values for potential evapo- transpiration according
to
* 5 different methods, namely; Priestly/Taylor, Penman, Monteith-Rijtema, Makkink
and
* Ritchie (soil evaporation). The algorythms were copied entirely from the model
* SWATRE as coded by Wesseling et al., 1989 (with permission)
*****************************************************************
SET STATUS OFF
SET TALK OFF
SET ECHO OFF
CLEAR SCREEN
CLEAR
SET DECIMAL TO 15
* Setting DECIMAL to 15 provides the highest level of precision possible
* in CLIPPER for any mathematical computations involving small numbers
set color to W/B, N/R,

STORE .F. TO CHANGE

frame = CHR(201) + CHR(205) + CHR(187) + CHR(186) + ;
     CHR(188) + CHR(205) + CHR(200) + CHR(186) + ;
     CHR(32)

STORE  1 to TOP
STORE  0 to LEFT
STORE 20 to BOTTOM
STORE 79 to RIGHT

@ TOP,LEFT,BOTTOM,RIGHT BOX FRAME
@ 2,3 SAY "POTEVAP: A program to estimate potential evapo-transpiration"
@ 3,3 SAY "        for use in the model DISTHMOD"

* NOTE: originally I set the values of the following constants and
* variables from here in the program. For increased flexibility I now read
* them from the SETUP file. This allow them to be changed without having
* to edit or recompile the program. I still need to check and justify the
* selected values
* mlai     = 0.0 & Leaf area index used in Ritchie equation
* mgamma   = 0.66713 & psycrometer constant used in all equations
* ptconst  = 1.35 & emperical constant for PT eqn. Swatre calls this alpha
* malbedo  = range from 0.08 to 0.14 wet to dry bare soil and 0.95 snow
* mcofnga  = 0.54 Transformation coefficients used in SWATRE to convert
* mcofngb  = -4.0 between NET and GLOBAL radiation. Vary by crop type.
```

```
* mewetlo = 0.7 & Constant in SWATRE if ewet < ewetlo rs = rsmin
* mewethi  = 1.1 & Constant in SWATRE if ewet > ewethi rs = rsmax
* mrsmin   = 33.0 & Minimum value for canopy or surface resistance (s/m)
* mrsmax   = 150.0 & Maximum value for canopy/surface resistance (s/m)
* note: look up reasonable values for mrsmin and mrsmax from examples

USE SETUP

METDATA  = TRIM(LTRIM(METFILE))
mlai     = lai
mgamma   = gamma
mptconst = ptconst
* malbedo  = albedo & maybe I should read in a daily value for albedo
mcofnga  = cofnga
mcofngb  = cofngb
mewetlo = ewetlo
mewethi  = ewethi
mrsmin   = rsmin
mrsmax   = rsmax
rchoice  = rtype
* DeltaT   = timestep

@ 5, 3  SAY "Constants and coefficients used in present calculations"
@ 6, 3  SAY "Gamma  CofngA CofngB ewetlo ewethi rsmin rsmax lai P-T Const"
@ 7, 3  SAY mgamma  picture   "#.####"
@ 7, 11 SAY mcofnga picture   "#.##"
@ 7, 18 SAY mcofngb picture  "##.#"
@ 7, 25 SAY mewetlo picture   "#.#"
@ 7, 32 SAY mewethi picture   "#.#"
@ 7, 39 SAY mrsmin  picture  "##.#"
@ 7, 44 SAY mrsmax  picture "###.#"
@ 7, 50 SAY mlai     picture   "#.#"
@ 7, 55 SAY mptconst picture  "#.##"

* we need a conversion constant to convert W/m2 (which is J/sec/m2) to
* kg/m2/timestep
* The SWATRE conversion is for a time step of 1 day using:
* (60*60*24)= 86400 sec/day / 2.541*10^6 J/kg (the latent heat of
* vaporisation of water) to give 0.0352 kg/m2/day.
* A vapour flux of 1 kg/m2/day is equivalent to evaporation of 1 mm per day
* SWATRE uses cm/day for evaporation so changes 0.0352 to 0.00352 as the
* factor. This model needs to be able to handle either daily or hourly data
* and to keep units in millimeters so it computes a base conversion factor of:
* (60*60*24) = 86400 sec/day /2.541*10^6 J/kg = 0.0352

convert = (60*60*24)/(2.541*10^(6))

* convert = 0.0352
* convert  = ((60*60*24)/(2.541*10^(6)))
* This conversion factor will convert from W/m2 to mm of evaporation/day
* I then have to divide by 24 to get mm/hr when I am using a 1 hour time
* step

* Declare and zero all variables used in any of the following prodecures
ewet   = 0.0  && mm/day evaporation due to radiative input in Monteith
```

```
temk  = 0.0  && temperature in degrees K
wed   = 0.0  && intermediate coefficient in cumputing satvap & slope
satvap = 0.0  && saturated vapour pressure estimate as fn(temk)
vpd   = 0.0  && vapour pressure deficit (Vs - Va) sat - actual vp
rnet1  = 0.0  && net radiation according to Penman equation estimate
rnet2  = 0.0  && net radiation estimate as per SWATRE using crop coeffs
rnet   = 0.0  && choice of rnet1 or rnet2 used in this run
slope  = 0.0  && slope of temp-vapour pressure curve also called delta
rglob  = 0.0  && global short wave incoming radiation (direct and diffuse)
mwind  = 0.0  && wind speed in m/s averaged over day or hour time periods
priest = 0.0  && my name for potential evaporation by the priestly eqn
mont   = 0.0  && my name for potential evaporation by the Monteith eqn
eopen  = 0.0  && SWATRE symbol for potential ET by the Penman eqn
emak   = 0.0  && SWATRE symbol for potential ET by the Makkink eqn
atmeva = 0.0  && SWATRE symbol for potential ET by the Ritchie eqn

@ 9, 3  SAY "Input data for Julian day: "
@ 9, 40 SAY "Date: "
@ 9, 65 SAY "Hour: "

@ 10, 3 SAY "Radiation Temperature (C)  RH (fraction)  Wind Speed Deg Cloud "

@ 13, 3 SAY "Intermediate calculations and data for evapo-transpiration"
@ 14, 3 SAY "Albedo Temp (K) wed  satvap  slope  vpd  rnet1 rnet2 ewet ra    rs"

@ 17, 3 SAY "Evapo-transpiration estimates for current day and hour"
@ 18, 3 SAY "Penman    Monteith    Priestly    Makkink    Ritchie"

USE &METDATA
GO TOP
DO WHILE .not. eof() .AND. NOABORT()

   DO INITIAL
   DO PRIESTLY
   DO MAKKINK
   DO RITCHIE
   DO MONTEITH
   DO PENMAN

   @ 19, 5  SAY EOPEN  PICTURE "#.####"   && Penman estimate
   @ 19, 15 SAY MONT   PICTURE "#.####"   && Monteith estimate
   @ 19, 27 SAY PRIEST PICTURE "#.####"   && Priestly-Taylor estimate
   @ 19, 39 SAY EMAK   PICTURE "#.####"   && Makkink estimate
   @ 19, 50 SAY ATMEVA PICTURE "#.####"   && Ritchie estimate
   SKIP
ENDDO
RETURN
@ 22, 20 SAY "Program completed! "
***************************************************************
FUNCTION NOABORT
***************************************************************
* Returns a value of .T. in all cases EXCEPT when the ESC key is pressed
* If ESC is pressed when NOABORT is being evaluated it returns .F. and
* al alternate activity may be programmed (in above program I abort prog)
```

```
 RETURN (INKEY() <> 27 )
*****************************************************************
PROCEDURE Initial
*****************************************************************
* This procedure calculates the initial intermediate variables required for all (or most) of the
* individual evapo-transpiration equations (ie temk, wed, satvap, slope, vpd, rnet (1 and 2)
*****************************************************************
malbedo  = albedo
mwind   = wind
rglob   = radia
temk    = temp + 273.15
wed     = (0.058 * temk) - 2.1938
satvap  = 1.332 * EXP((1.08872 * temk - 276.4484) /wed)
slope   = (13.7315 * satvap)/ (wed**2)
vpd     = (1.0 - rh) * satvap
mcloud  = degcld

* The equation for RNET1 is meant for use ONLY with the Penman equation.
* Monteith, Priestly and Ritchie are supposed to use the second emperical
* equation RNET2 for converting. I use the equation RNET1 for determining
* all computations of net radiation as I have no evgetation information.

rnet1  = (1.0 - malbedo) * rglob - 5.67*10^(-8) * (temk**4) * ;
         (0.47 - 0.067 * sqrt(satvap * rh)) *;
         (1.0 -0.8 * mcloud)

rnet2  = mcofnga * rglob + mcofngb

IF RCHOICE = 1
 rnet= rnet1
ELSE
 rnet = rnet2
ENDIF

today = trim(month)+" "+Ltrim(STR(DAY))+", 1988    "

@  9, 32 SAY julian picture "###"
@  9, 46 SAY today
@  9, 71 SAY hour picture "##"

@ 11, 5  SAY rglob  picture  "###.#"
@ 11, 15 SAY temp   picture  "###.##"
@ 11, 32 SAY rh     picture  "##.##"
@ 11, 47 SAY mwind  picture   "##.##"
@ 11, 59 SAY mcloud picture   "#.##"

@ 15, 4  SAY malbedo  picture   "#.##"
@ 15, 11 SAY temk     picture "###.#"
@ 15, 19 SAY wed      picture  "##.#"
@ 15, 25 SAY satvap   picture  "##.##"
@ 15, 32 SAY slope    picture "##.##"
@ 15, 38 SAY vpd      picture "##.##"
@ 15, 44 SAY rnet1    picture "###.#"
```

```
@ 15, 50 SAY rnet2   picture "###.#"
@ 15, 57 SAY ewet    picture  "#.#"

* for calculation by Priestly-Taylor global input radiation (Rglob=radia)
* needs to be converted into Rnet according to the formula above (also
* Ritchie)
*****************************************************************
PROCEDURE Priestly
*****************************************************************
* This procedure  calculates an estimate for evapotranspiration based on  the equation
* presented by Priestly and Taylor (1972). The implemented  algorithm was copied from
* the model SWATRE by Wesseling et al., 1989
*****************************************************************
PRIEST = (CONVERT/24) * rnet * MPTCONST * SLOPE / (SLOPE + MGAMMA)
if PRIEST <= 0.00000000000001
   PRIEST = 0.00
endif
REPLACE PRIESTLY WITH PRIEST
* end of Priestly/Taylor calculation
*****************************************************************
PROCEDURE MONTEITH
*****************************************************************
* This procedure  calculates an estimate for evapotranspiration based on  the modified
* Penman equation as presented by Monteith (1965) & Rijtema  (1965). It was copied
from
* the model SWATRE by Wesseling et al., 1989
*****************************************************************
* NOTE: that we have no crop growth so funcch must be << 0.18e-7 and we
* do not need to compute the crop height coefficient function (funcch)

* if cropht >= cofchx
*      funcch = cofcha * cropht ** cofchb
* elseif cropht < cofchx
*      funcch = cofchc * cropht ** cofchd
* endif

* if funcch > cofchm
*      funcch = cofchm
* elseif funcch < 0.18*10^(-7)
*      funcch = 0.18*10^(-7)
* endif

funcch = 0.18*10^(-7)

* values of 0 for wind result in division by 0 and must be trapped
if mwind <= 0.0
   mwind = 0.0001
endif

ra =  6.43*10^(-6) / (funcch * mwind **.75)

ewet = 0.00352 * (slope * rnet + 1210.0 / ra * vpd) / (slope + mgamma)
* NOTE: Since I have no crop cover it doesn't make sense to convert from
* global radiation (rglob) to net radiation (rnet) using an emperical
* function based on crop characterastics. I think I should use the
```

```
* same equation as used for the Penman equation to convert from global
* to net radiation. THEREFORE USE RNET1 instead of RNET2

if ewet < mewetlo
     rs = mrsmin
elseif ewet > mewethi
     rs = mrsmax
else
   rs = 10.0**(log10(mrsmin) + (ewet-mewetlo) / (mewethi - mewetlo);
          * (log10(mrsmax) - log10(mrsmin)))
endif

* Note: the log function used here is log base 10. Wesseling uses
* a function called dlog10 which is obviously the double precision log to
* the base 10. I defined a similar function in Clipper but have to limit
* the significance to 15 decimal places which is not likely as precise as
* the double precision defined by Wesseling.

* I compute log10 according to Log10 = log(n)/2.302585
* I am still confused about using the natural log vs log base 10.
* but I tried both and only Log(n)/2.302585 produced reasonable results

@ 15, 61 SAY ra      picture "###.#"
@ 15, 67 SAY rs      picture "###.#"

mont = ((slope + mgamma) / (slope + mgamma * (1.0 + rs/ra))) * (ewet/2.4)

* NOTE: I divide ewet here by 2.4 because I need to convert from cm/day
* estimates made in ewet to mm/hour
* ie. cm/day to mm/hr -> 1day/24hr * 10 mm/1 cm = 10/24 = 1/2.4 or .41666
if mont < 0.000000000000001
   mont = 0.0000
endif

REPLACE MONTEITH WITH MONT
*****************************************************************
PROCEDURE PENMAN
*****************************************************************
* This procedure calculates an estimate for potential evaporation from an open water
* surface using the equation of Penman (1948)
* The algorithm was copied from SWATRE by Wesseling et al., 1989
*****************************************************************

eopen = (convert/24) * (slope * rnet + mgamma * 28.368 *;
   0.26 * (0.54 * mwind + 0.5) * vpd) /;
   (slope + mgamma)

if eopen <= 0.000000000000001
   eopen = 0.0
endif

REPLACE PENMAN WITH EOPEN

* end of Penman calculation
```

```
*****************************************************************
PROCEDURE MAKKINK
*****************************************************************
* This procedure  calculates an estimate for evapotranspiration based on *
* the simple Makkink equation Makkink (19xx)                          *
* The algorithm was copied from the model SWATRE by Wesseling et al 1989 *
*****************************************************************

emak = (convert/24) * 0.65 * rglob * slope / (slope + mgamma)

if emak < 0.0
   emak = 0.0
endif

REPLACE MAKKINK WITH emak

* end of code for Makkink Calculation here
*****************************************************************
PROCEDURE RITCHIE
*****************************************************************
* This procedure  calculates an estimate for soil evaporation based on  the simple Ritchie
* equation Ritchie (1972)
* The algorithm was copied from the model SWATRE by Wesseling et al 1989
*****************************************************************

atmeva = (convert/24)*(slope /(slope + mgamma))* rnet *exp(-0.39 * mlai)

* note: this equation also calls for dexp() NOT exp() but mlai = 0 for me
* so it is dexp(0), I can look this up and substitute a constant value.
if atmeva <= 0.000000000000001
   atmeva = 0.0
endif

REPLACE RITCHIE WITH atmeva
*****************************************************************
*****************************************************************
FUNCTION log10

PARAMETER n
SET DECIMAL TO 15
RETURN(Log(n)/2.302585)
*****************************************************************
```

APPENDIX 9

FLOODVOL PROGRAM LISTING

```
*****************************************************************
* Program FLOODVOL
*****************************************************************
Program to process a gridded DEM data set in dBase III format to calculate and assign for
* every grid cell, the volume at which that cell will first be flooded (or ponded).
*****************************************************************
Written by R. A. Mac Millan
* Date: Feb 26, 1991 ; March 4, 1991; July 22, 1991       Version: 1.0; 1.1; 1.2
*****************************************************************
SET TALK OFF
SET ECHO OFF
CLEAR ALL
CLEAR
SET DECIMAL TO 15
PONDFILE = 'PONDATA'
GRIDFILE = 'LUNTYGRD'
CHEKFILE = 'PONDCHEK'
THISELEV = 0.0
NEXTELEV = 0.0
THISHED  = 0
SPILELEV = 0
PONDAREA = 0
TOTVOL  = 0
NOCHANGE = .F.
SELECT A
USE &PONDFILE
SELECT C
USE &CHEKFILE
SET SAFETY OFF
ZAP
SELECT B
USE &GRIDFILE
GO TOP
@ 20, 2  SAY "Setting shednow, parea and floodvol to original values"
DO WHILE .NOT. EOF()
 REPLACE SHEDNOW WITH SHEDNO
 REPLACE PAREA WITH 0.0
 REPLACE FLODVOL WITH  0.0
 SKIP
ENDDO
@ 20, 2  CLEAR
@ 20, 2  SAY "Indexing LuntyGRD to BOTTOMUP!"
INDEX ON   ((SHEDNOW*10^8) + (ELEV*10^5) + (1400 - UPSLOPE)) TO
BOTTOMUP
* BOTTOMUP index expression was:
* ((SHEDNOW*10^5)+(ELEV*10^2)+(1/UPSLOPE))
@ 20, 2  CLEAR
*****************************************************************
```

```
****************************************************************
* This index sorts the grid elements by current shed number by elevation by
* upslope element count. The resulting order is from the smallest to largest
* shednumber and lowest to highest elevation within each watershed along any
* given flow path. The addition of the upslope element count to the index
* expression is essential to ensure that of any group of cells at the same
* elevation the 'downslope cell' in terms of flow paths is always processed
* first. If this was not done, it could not be guaranteed that the 'last' or
* lowest cell in any catchment would be the 'pitcentre cell'
* The first record encountered in each watershed must therefore be the lowest
* (ie. the pit centre) and the last must be the highest point in the watershed
****************************************************************
SELECT A   && ie PONDFILE

GO BOTTOM
MAXSHED = RECNO()
GO TOP

@ 2,  2 SAY 'PROCESSING SHEDNO.........: '
@ 4,  2 SAY 'POUR ELEVATION IS.........: '
@ 6,  2 SAY 'NEXT ELEVATION IS.........: '
@ 8,  2 SAY 'ELEVATION DIFF IS.........: '
@ 10, 2 SAY 'VOLUME WHEN FULL IS.......: '
@ 12, 2 SAY 'VOLUME TO FIRST FLOOD IS..: '

DO WHILE .NOT. EOF()

* Read in the pond data stats that control computations

 THISVOL  = PREVOL
 TOTVOL   = TOTALVOL
 CENTREC  = PITREC
 THISHED  = SHEDNO
 NEXT2    = PITUP
 SPILELEV = POURELEV
 NOCHANGE = .F.

 @ 2, 31 SAY THISHED PICTURE "999"

 DO CASE

  CASE THISHED < 116    && Do normal fill of first order ponds
   SELECT B             && ie use Grid data set (Lunty1)
   SET INDEX TO BOTTOMUP
   GOTO CENTREC
   PONDAREA = 0
   THISVOL  = 0.0

   DO WHILE ELEV <= SPILELEV .AND. SHEDNOW = THISHED
             N    = 0
             THISELEV  = ELEV
             LASTAREA  = PONDAREA

             DO WHILE ELEV = THISELEV
                    N = N + 1
```

```
                PONDAREA = PONDAREA + 1
                SKIP
            ENDDO

            LASTREC = RECNO()
            NEXTELEV = ELEV
            ELEVDIFF = NEXTELEV - THISELEV

            @ 4, 31 SAY SPILELEV PICTURE "999.9"
            @ 6, 31 SAY NEXTELEV PICTURE "999.9"
            @ 8, 31 SAY ELEVDIFF PICTURE "99.9"

            LASTVOL = THISVOL
            THISVOL = LASTVOL + (PONDAREA * ELEVDIFF)
            @ 10, 31 SAY THISVOL PICTURE "9999.99"
            @ 12, 31 SAY LASTVOL PICTURE "9999.99"

            IF LASTVOL <= 0.0
                LASTVOL = 0.01
            ENDIF

            DO WHILE N > 0
                SKIP - 1
                REPLACE FLODVOL WITH LASTVOL
                REPLACE PAREA WITH PONDAREA
                N = N - 1
            ENDDO

            GOTO LASTREC
    ENDDO
        CASE THISHED >= 116

        IF THISHED = 116
            SELECT B
            CLOSE INDEX
            GO TOP
            @ 20, 2 SAY "Updating SHEDNOW with PITUP for all records"
            SET RELATION TO SHEDNO INTO A
            DO WHILE .NOT. EOF()
                IF A->PITUP > 115
                    REPLACE SHEDNOW WITH A->PITUP
                ENDIF
                SKIP
            ENDDO
            @ 20, 2 CLEAR

            SET RELATION TO
            SET INDEX TO BOTTOMUP
            @ 20, 2 SAY "Reindexing LUNTY1 to BOTTOMUP!"
            REINDEX
            @ 20, 2 CLEAR
        ENDIF
    SELECT B
    SET INDEX TO BOTTOMUP
    GOTO CENTREC
```

```
    PONDAREA  = 0.0

* The loop below climbs up through the data set from the pit centre to the
* first grid element that has not yet been assigned a positive value for
* FLODVOL. It skips over those cells with a previously computed FLODVOL
* and stops at the first cell with a zero FLODVOL. This cell is the
* starting point for the next round of volume calculations

    DO WHILE  FLODVOL > 0.0
            PONDAREA  = PONDAREA + 1
            THISELEV = ELEV
            SKIP
    ENDDO

* This is just a temporary check inserted to investigate whether there is
* a change in elevation between the last record with an assigned floodvol
* and the first without (there should be a change). If there is no change
* then NOCHANGE is true and .T. will be stored to the field FLAT in the
* file PONDCHEK. This will tell me that there is an error in the data set
* that will cause the program to compute an incorrect volume for this pond
    IF ELEV = THISELEV
            NOCHANGE = .T.
    ENDIF
* This is the main routine for computing pond volume at any given depth.
* It processes all cells from the starting cell until the first cell that
* is higher than the previously determined pour elevation. It steps up
* from the starting cell to the first cell that is higher than it in each
* pass through the loop.

    DO WHILE ELEV <= SPILELEV .AND. SHEDNOW = THISHED
            N       = 0
            LASTAREA = PONDAREA

            DO WHILE ELEV = THISELEV
                N = N + 1
                PONDAREA = PONDAREA + 1
                SKIP
            ENDDO

            LASTREC  = RECNO()
            NEXTELEV = ELEV
            ELEVDIFF = NEXTELEV - THISELEV

            @ 4, 31 SAY SPILELEV PICTURE "999.9"
            @ 6, 31 SAY NEXTELEV PICTURE "999.9"
            @ 8, 31 SAY ELEVDIFF PICTURE "99.9"

            LASTVOL = THISVOL
            THISVOL = LASTVOL + (PONDAREA * ELEVDIFF)
            @ 10, 31 SAY THISVOL PICTURE "9999.99"
            @ 12, 31 SAY LASTVOL PICTURE "9999.99"

            DO WHILE N > 0
                SKIP - 1
                REPLACE FLODVOL WITH LASTVOL
```

```
                REPLACE PAREA WITH PONDAREA
                N = N - 1
            ENDDO

            GOTO LASTREC
            THISELEV = NEXTELEV
    ENDDO

    IF NEXT2 > 115
            SELECT B
            CLOSE INDEX
            GO TOP
            @ 20, 2 SAY "Replacing shednow "+LTRIM(TRIM(STR(THISHED)))     +;
                        " with "+LTRIM(TRIM(STR(NEXT2)))
            REPLACE ALL SHEDNOW WITH NEXT2 FOR SHEDNOW =
            THISHED
            @ 20, 2 CLEAR
            @20 , 2 SAY "Reindexing BOTTOMUP!"
            SET INDEX TO BOTTOMUP
            REINDEX
            @ 20, 2 CLEAR
    ENDIF
  ENDCASE

  SELECT C
  APPEND BLANK
  REPLACE SHEDNO WITH THISHED
  REPLACE POURELEV WITH SPILELEV
  REPLACE PITVOL WITH LASTVOL
  REPLACE PITAREA WITH LASTAREA
  REPLACE PONDELEV WITH THISELEV
  REPLACE TOTALVOL WITH TOTVOL
  REPLACE FLAT WITH NOCHANGE

  SELECT A
  GOTO THISHED
  SKIP
ENDDO
```

APPENDIX 10

OUTPUT FROM SNOWMELT MODEL

FOR REFERENCE DEPTHS FROM 5 - 70 CM

A10.1 Introduction

The data presented below represent hourly estimates of the volume of water (mm) released by melting from a snow pack of a specified depth. Estimates are in mm of water per unit area (25 m^2) for the present study). Estimates are presented for "reference depths" of 5, 10, 15, 20, 30, 40, 50, 60, and 70 cm. Estimates were made for "reference depths" up to 200 cm but are not presented since the maximum depth of snow recorded by the snow pack survey in March, 1989 was 61 cm. The time range reported extends from the first hour of available meteorological data to the last hour for which any snow melt was estimated for the deepest reported snow depth (70 cm). Air temperature in degrees C is included in the table.

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
March	22	81	16	-2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	17	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	18	-1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	19	-1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	20	-2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	21	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	22	-3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	23	-3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	22	81	24	-4.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	1	-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	2	-5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	3	-6.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	4	-6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	5	-7.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	6	-7.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	7	-7.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	8	-8.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	9	-8.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	10	-5.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	11	-4.0	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	12	-0.9	2.35	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	13	0.9	3.16	1.94	0.10	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	14	2.0	4.06	2.25	1.78	0.15	0.00	0.00	0.00	0.00	0.00
March	23	82	15	3.3	0.69	2.33	1.80	1.58	0.00	0.00	0.00	0.00	0.00
March	23	82	16	4.2	0.00	2.28	1.71	1.49	0.21	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
March	23	82	17	4.5	0.00	1.89	1.33	1.13	0.98	0.00	0.00	0.00	0.00
March	23	82	18	4.1	0.00	1.16	0.73	0.59	0.48	0.00	0.00	0.00	0.00
March	23	82	19	3.4	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	20	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	21	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	22	-0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	23	-1.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	23	82	24	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	1	-1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	2	-1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	3	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	4	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	5	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	6	-1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	7	-2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	8	-3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	9	-2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	10	-0.9	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	11	0.5	0.00	1.98	0.78	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	12	1.2	0.00	2.95	1.62	1.21	0.00	0.00	0.00	0.00	0.00
March	24	83	13	2.3	0.00	4.10	2.08	1.68	1.35	0.00	0.00	0.00	0.00
March	24	83	14	2.4	0.00	0.10	2.29	1.81	1.52	1.13	0.00	0.00	0.00
March	24	83	15	3.4	0.00	0.00	2.47	1.92	1.62	1.52	0.00	0.00	0.00
March	24	83	16	3.7	0.00	0.00	2.17	1.59	1.31	1.22	0.83	0.00	0.00
March	24	83	17	4.2	0.00	0.00	1.72	1.19	0.95	0.88	0.85	0.00	0.00
March	24	83	18	3.5	0.00	0.00	0.83	0.47	0.33	0.28	0.26	0.00	0.00
March	24	83	19	2.3	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	20	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	21	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	22	-0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	23	-0.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	24	83	24	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	1	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	2	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	3	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	4	-3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	5	-4.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	6	-4.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	7	-3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	8	-3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	9	-3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	10	-2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	11	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	12	-2.0	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	13	-1.9	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	14	-1.7	0.00	0.00	0.58	0.03	0.00	0.00	0.00	0.00	0.00
March	25	84	15	-1.2	0.00	0.00	0.64	0.09	0.00	0.00	0.00	0.00	0.00
March	25	84	16	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	17	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	18	-1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
March	25	84	19	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	20	-1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	21	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	22	-1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	23	-1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	25	84	24	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	1	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	2	-1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	3	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	4	-1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	5	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	6	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	7	-2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	8	-3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	9	-3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	10	-3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	11	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	12	-2.9	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	13	-2.4	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	14	-2.1	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	15	-1.7	0.00	0.00	0.66	0.04	0.00	0.00	0.00	0.00	0.00
March	26	85	16	-1.4	0.00	0.00	0.73	0.07	0.00	0.00	0.00	0.00	0.00
March	26	85	17	-1.5	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	18	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	19	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	20	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	21	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	22	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	23	-1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	26	85	24	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	1	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	2	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	3	-2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	4	-2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	5	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	6	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	7	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	8	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	9	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	10	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	11	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	12	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	13	-0.5	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	14	-0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	15	-0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	16	-0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	17	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	18	-0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	19	-1.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	20	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
March	27	86	21	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	22	-1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	23	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	27	86	24	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	1	-2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	2	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	3	-3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	4	-3.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	5	-3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	6	-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	7	-4.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	8	-4.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	9	-4.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	10	-4.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	11	-3.8	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	12	-3.4	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	13	-3.2	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	14	-3.0	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	15	-2.9	0.00	0.00	1.47	0.10	0.00	0.00	0.00	0.00	0.00
March	28	87	16	-2.7	0.00	0.00	1.14	0.32	0.00	0.00	0.00	0.00	0.00
March	28	87	17	-2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	18	-2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	19	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	20	-3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	21	-3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	22	-3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	23	-3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	28	87	24	-3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	1	-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	2	-3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	3	-3.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	4	-3.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	5	-3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	6	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	7	-3.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	8	-2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	9	-2.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	10	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	11	-1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	12	-1.2	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
March	29	88	13	-0.7	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00
March	29	88	14	0.0	0.00	0.00	0.00	1.81	1.32	0.53	0.00	0.00	0.00
March	29	88	15	1.3	0.00	0.00	0.00	2.02	1.50	1.37	1.14	0.00	0.00
March	29	88	16	3.5	0.00	0.00	0.00	1.98	1.46	1.35	1.30	1.10	0.00
March	29	88	17	4.5	0.00	0.00	0.00	1.63	1.15	1.05	1.01	0.99	0.00
March	29	88	18	4.5	0.00	0.00	0.00	1.08	0.71	0.64	0.61	0.60	0.00
March	29	88	19	4.3	0.00	0.00	0.00	0.33	0.12	0.08	0.07	0.06	0.00
March	29	88	20	2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	21	0.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	22	-0.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
March	29	88	23	-1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	29	88	24	-2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	1	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	2	-2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	3	-2.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	4	-2.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	5	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	6	-4.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	7	-4.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	8	-4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	9	-3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	10	-1.0	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00
March	30	89	11	1.2	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00
March	30	89	12	2.8	0.00	0.00	0.00	2.25	0.96	0.00	0.00	0.00	0.00
March	30	89	13	3.8	0.00	0.00	0.00	2.87	1.75	1.38	0.59	0.00	0.00
March	30	89	14	4.9	0.00	0.00	0.00	3.36	1.92	1.74	1.68	1.62	0.81
March	30	89	15	5.9	0.00	0.00	0.00	3.76	1.94	1.75	1.68	1.65	1.63
March	30	89	16	7.3	0.00	0.00	0.00	4.14	1.88	1.70	1.63	1.60	1.59
March	30	89	17	7.9	0.00	0.00	0.00	0.42	1.66	1.50	1.44	1.42	1.40
March	30	89	18	7.4	0.00	0.00	0.00	0.00	1.08	0.96	0.92	0.90	0.89
March	30	89	19	6.5	0.00	0.00	0.00	0.00	0.43	0.36	0.34	0.33	0.32
March	30	89	20	3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	21	0.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	22	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	23	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	30	89	24	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	1	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	2	-0.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	3	-1.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	4	-1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	5	-1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	6	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	7	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	8	-2.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	9	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	10	1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	11	3.0	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00
March	31	90	12	4.2	0.00	0.00	0.00	0.00	1.81	1.25	0.65	0.13	0.00
March	31	90	13	5.3	0.00	0.00	0.00	0.00	2.38	2.09	2.00	1.96	1.69
March	31	90	14	6.1	0.00	0.00	0.00	0.00	2.49	2.16	2.06	2.02	2.00
March	31	90	15	7.3	0.00	0.00	0.00	0.00	2.61	2.24	2.14	2.10	2.08
March	31	90	16	7.1	0.00	0.00	0.00	0.00	1.86	1.54	1.46	1.43	1.41
March	31	90	17	6.7	0.00	0.00	0.00	0.00	1.09	0.88	0.83	0.81	0.80
March	31	90	18	6.5	0.00	0.00	0.00	0.00	1.13	0.91	0.86	0.84	0.83
March	31	90	19	5.7	0.00	0.00	0.00	0.00	0.69	0.54	0.51	0.50	0.49
March	31	90	20	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	21	1.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	22	0.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
March	31	90	23	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	31	90	24	-0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
April	1	91	1	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	2	-0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	3	-1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	4	-1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	5	-0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	6	-0.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	7	-1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	8	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	9	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	10	1.8	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00	0.00
April	1	91	11	3.3	0.00	0.00	0.00	0.00	1.57	0.91	0.30	0.00	0.00
April	1	91	12	4.4	0.00	0.00	0.00	0.00	2.19	1.60	1.48	1.25	0.86
April	1	91	13	5.3	0.00	0.00	0.00	0.00	2.58	1.83	1.69	1.63	1.60
April	1	91	14	6.1	0.00	0.00	0.00	0.00	2.88	1.96	1.80	1.74	1.72
April	1	91	15	6.6	0.00	0.00	0.00	0.00	3.05	1.97	1.81	1.75	1.72
April	1	91	16	7.2	0.00	0.00	0.00	0.00	2.88	1.67	1.52	1.46	1.43
April	1	91	17	7.6	0.00	0.00	0.00	0.00	2.41	1.17	1.03	0.99	0.96
April	1	91	18	7.8	0.00	0.00	0.00	0.00	1.77	0.69	0.59	0.56	0.54
April	1	91	19	7.7	0.00	0.00	0.00	0.00	0.83	0.15	0.10	0.08	0.07
April	1	91	20	4.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	21	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	22	-0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	23	-0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	1	91	24	-0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	1	-1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	2	-1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	3	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	4	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	5	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	6	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	7	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	8	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	9	-0.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	10	1.3	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	0.00
April	2	92	11	2.5	0.00	0.00	0.00	0.00	2.37	0.38	0.00	0.00	0.00
April	2	92	12	3.8	0.00	0.00	0.00	0.00	0.17	1.24	0.76	0.12	0.00
April	2	92	13	5.2	0.00	0.00	0.00	0.00	0.00	1.60	1.40	1.34	0.92
April	2	92	14	6.7	0.00	0.00	0.00	0.00	0.00	1.80	1.58	1.51	1.48
April	2	92	15	7.4	0.00	0.00	0.00	0.00	0.00	1.50	1.29	1.23	1.21
April	2	92	16	8.2	0.00	0.00	0.00	0.00	0.00	1.48	1.26	1.19	1.16
April	2	92	17	8.5	0.00	0.00	0.00	0.00	0.00	1.00	0.83	0.77	0.75
April	2	92	18	7.2	0.00	0.00	0.00	0.00	0.00	1.03	0.87	0.83	0.81
April	2	92	19	5.6	0.00	0.00	0.00	0.00	0.00	0.47	0.39	0.36	0.35
April	2	92	20	3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	21	2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	22	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	23	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	2	92	24	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	1	-0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	2	0.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
April	3	93	3	-0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	4	-0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	5	-0.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	6	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	7	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	8	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	9	-0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	10	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	11	1.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	12	2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	13	2.8	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00
April	3	93	14	4.8	0.00	0.00	0.00	0.00	0.00	2.22	1.00	0.01	0.00
April	3	93	15	4.3	0.00	0.00	0.00	0.00	0.00	0.33	0.21	0.19	0.00
April	3	93	16	4.3	0.00	0.00	0.00	0.00	0.00	0.35	0.24	0.21	0.00
April	3	93	17	4.2	0.00	0.00	0.00	0.00	0.00	0.78	0.64	0.61	0.45
April	3	93	18	4.3	0.00	0.00	0.00	0.00	0.00	1.00	0.79	0.74	0.72
April	3	93	19	4.7	0.00	0.00	0.00	0.00	0.00	0.32	0.20	0.17	0.16
April	3	93	20	2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	21	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	22	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	23	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	3	93	24	-0.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	1	-1.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	2	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	3	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	4	-1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	5	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	6	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	7	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	8	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	9	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	10	2.4	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.00
April	4	94	11	4.1	0.00	0.00	0.00	0.00	0.00	1.73	0.56	0.00	0.00
April	4	94	12	5.6	0.00	0.00	0.00	0.00	0.00	2.36	1.87	1.53	1.00
April	4	94	13	6.6	0.00	0.00	0.00	0.00	0.00	2.81	2.19	2.08	2.03
April	4	94	14	7.1	0.00	0.00	0.00	0.00	0.00	2.98	2.24	2.11	2.06
April	4	94	15	8.1	0.00	0.00	0.00	0.00	0.00	3.18	2.33	2.19	2.14
April	4	94	16	8.2	0.00	0.00	0.00	0.00	0.00	2.66	1.83	1.71	1.67
April	4	94	17	7.8	0.00	0.00	0.00	0.00	0.00	1.76	1.12	1.04	1.01
April	4	94	18	8.1	0.00	0.00	0.00	0.00	0.00	1.46	0.83	0.76	0.73
April	4	94	19	7.8	0.00	0.00	0.00	0.00	0.00	0.82	0.38	0.33	0.32
April	4	94	20	6.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	21	4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	22	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	23	-0.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	4	94	24	-1.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	1	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	2	-1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	3	-1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	4	-1.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
April	5	95	5	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	6	-2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	7	-1.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	8	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	9	1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	10	3.6	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00
April	5	95	11	8.0	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00
April	5	95	12	8.0	0.00	0.00	0.00	0.00	0.00	2.80	0.98	0.00	0.00
April	5	95	13	7.8	0.00	0.00	0.00	0.00	0.00	2.95	1.42	1.20	0.52
April	5	95	14	7.2	0.00	0.00	0.00	0.00	0.00	1.37	1.06	0.97	0.94
April	5	95	15	7.0	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.58	0.56
April	5	95	16	6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.18	0.16
April	5	95	17	5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.23	0.21
April	5	95	18	4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.22	0.20
April	5	95	19	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	20	1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	21	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	22	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	23	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	5	95	24	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	1	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	2	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	3	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	4	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	5	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	6	-2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	7	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	8	-2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	9	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	10	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	11	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	12	5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00
April	6	96	13	6.8	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.71	0.00
April	6	96	14	7.2	0.00	0.00	0.00	0.00	0.00	0.00	1.26	1.11	0.95
April	6	96	15	7.8	0.00	0.00	0.00	0.00	0.00	0.00	1.27	1.10	1.05
April	6	96	16	7.5	0.00	0.00	0.00	0.00	0.00	0.00	1.23	1.06	1.01
April	6	96	17	6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.48	0.44
April	6	96	18	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.18	0.15
April	6	96	19	4.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	20	4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	21	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	22	2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	23	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	6	96	24	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	1	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	2	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	3	-0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	4	-0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	5	-0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	6	-0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
April	7	97	7	-0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	8	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	9	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	10	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	11	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	12	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	13	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00
April	7	97	14	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00
April	7	97	15	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	16	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	17	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00
April	7	97	18	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.05	0.00
April	7	97	19	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	20	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	21	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	22	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	23	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	7	97	24	-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	1	-5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	2	-7.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	3	-8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	4	-9.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	5	-9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	6	-9.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	7	-8.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	8	-6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	9	-4.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	10	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	11	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00
April	8	98	12	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	1.16	0.26	0.00
April	8	98	13	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	1.26	0.92	0.37
April	8	98	14	0.2	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.90	0.83
April	8	98	15	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.59	0.52
April	8	98	16	1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.19	0.15
April	8	98	17	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.10	0.06
April	8	98	18	1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.05	0.00
April	8	98	19	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	20	-1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	21	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	22	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	23	-3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	8	98	24	-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	1	-4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	2	-4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	3	-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	4	-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	5	-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	6	-5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	7	-5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	8	-5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
April	9	99	9	-3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	10	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	11	0.0	0.00	0.00	0.00	0.00	0.00	0.00	1.12	0.00	0.00
April	9	99	12	1.8	0.00	0.00	0.00	0.00	0.00	0.00	1.90	1.14	0.29
April	9	99	13	3.2	0.00	0.00	0.00	0.00	0.00	0.00	2.31	1.76	1.66
April	9	99	14	4.5	0.00	0.00	0.00	0.00	0.00	0.00	2.33	1.74	1.64
April	9	99	15	5.5	0.00	0.00	0.00	0.00	0.00	0.00	2.41	1.76	1.67
April	9	99	16	5.5	0.00	0.00	0.00	0.00	0.00	0.00	1.79	1.21	1.13
April	9	99	17	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.41	0.36
April	9	99	18	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.31	0.27
April	9	99	19	4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.15	0.11
April	9	99	20	3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	21	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	22	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	23	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	9	99	24	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	1	-4.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	2	-4.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	3	-5.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	4	-5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	5	-5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	6	-6.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	7	-5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	8	-3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	9	-0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	0.00
April	10	100	10	2.5	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.00	0.00
April	10	100	11	5.0	0.00	0.00	0.00	0.00	0.00	0.00	2.41	0.88	0.00
April	10	100	12	6.8	0.00	0.00	0.00	0.00	0.00	0.00	2.75	1.44	0.95
April	10	100	13	8.0	0.00	0.00	0.00	0.00	0.00	0.00	3.07	1.47	1.35
April	10	100	14	9.2	0.00	0.00	0.00	0.00	0.00	0.00	3.54	1.52	1.40
April	10	100	15	9.8	0.00	0.00	0.00	0.00	0.00	0.00	3.01	1.44	1.31
April	10	100	16	10.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	1.21
April	10	100	17	10.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.70
April	10	100	18	10.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.33
April	10	100	19	10.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.24
April	10	100	20	7.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	21	4.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	22	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	23	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	10	100	24	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	1	-1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	2	-0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	3	-0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	4	-1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	5	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	6	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	7	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	8	-1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	9	2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	10	5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
April	11	101	11	7.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.72	0.96
April	11	101	12	10.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.92	1.74
April	11	101	13	12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.15	1.95
April	11	101	14	13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.41	2.20
April	11	101	15	14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.42	2.19
April	11	101	16	15.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.09	1.85
April	11	101	17	15.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04	1.81
April	11	101	18	14.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	1.16
April	11	101	19	14.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.70
April	11	101	20	12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.17
April	11	101	21	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	22	4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	23	2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	11	101	24	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	1	2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	2	3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	3	3.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	4	4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	5	5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	6	6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	7	8.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	8	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00
April	12	102	9	11.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81	1.16
April	12	102	10	12.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.79	2.48
April	12	102	11	12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.17	2.81
April	12	102	12	13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.63	3.19
April	12	102	13	13.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.29	3.71
April	12	102	14	13.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.08	4.49
April	12	102	15	14.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.78	4.08
April	12	102	16	14.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.59	3.77
April	12	102	17	13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.80	2.86
April	12	102	18	12.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	2.54
April	12	102	19	11.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
April	12	102	20	10.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60
April	12	102	21	8.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	22	5.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	23	3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	12	102	24	2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	1	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	2	-1.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	3	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	4	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	5	-3.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	6	-2.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	7	-1.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	8	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	9	3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	10	6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20
April	13	103	11	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.53
April	13	103	12	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.17

Month	Day	Julian day	Hour	Temp Deg C	Melt Vol for 5 cm	Melt Vol for 10 cm	Melt Vol for 15 cm	Melt Vol for 20 cm	Melt Vol for 30 cm	Melt Vol for 40 cm	Melt Vol for 50 cm	Melt Vol for 60 cm	Melt Vol for 70 cm
April	13	103	13	11.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.90
April	13	103	14	12.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74
April	13	103	15	11.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.41
April	13	103	16	10.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.80
April	13	103	17	9.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.56
April	13	103	18	9.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.54
April	13	103	19	9.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95
April	13	103	20	8.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93
April	13	103	21	6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	22	3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	23	-0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	13	103	24	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	1	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	2	-3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	3	-4.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	4	-5.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	5	-5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	6	-5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	7	-4.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	8	-2.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
April	14	104	9	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
April	14	104	10	4.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95
April	14	104	11	7.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.72
April	14	104	12	10.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.69
April	14	104	13	11.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX 11

THE DISTHMOD SIMULATION MODEL

11.1 Introduction

This appendix provides an overview of the pre-processing operations required to be completed prior to operating DISTHMOD followed by a detailed description of the operational structure and programming algorithms adopted for the DISTHMOD model.

11.2 Preprocessing procedures

During pre-processing, estimates of potential evapo-transpiration or evaporation were produced using five different equations as presented by Belmans et al. (1983) (see Appendix 8). Estimates of hourly potential snowmelt were computed using a modification of the energy balance equation as presented by Williams (1988) (see Appendix 7). Estimates of snowmelt were produced for hypothetical bodies of snow with initial depths at time T_0 ranging from 5 to 200 mm. A scaling approach was used subsequently, during actual model runs, to apply these hypothetical estimates to actual grid locations based on the initial depth of snow at grid location at time T_0. The scaling approach was adopted so as to avoid having to compute potential snowmelt for every grid cell for every time step during which snow remained on surface of that cell.

The topological attributes (SHEDORD, DREC and FLODVOL) were calculated using specially written pre-processing routines. The field for current shed order (SHEDORD) is used to organise the initial watersheds from highest to lowest in order of decreasing pour elevation. The field DREC records a unique number identifying the record number of the grid element to which the current grid cell is computed to drain. This record pointer provides direct access to the location in memory of the record for the cell immediately down slope from any given grid cell and is used as a rapid way to locate that cell whenever it is necessary to pass runoff from a given cell to its downslope neighbour. The field FLODVOL contains an estimate of the volume of water that would have to accumulate in a given depression before a particular grid cell would first become flooded. A pre-processing routine is used to compute a volume to first flood (FLODVOL) for every cell in the data set for which flooding is possible.

11.3 Operational structure of the model

DISTHMOD stores all input data in one of five relational tables and outputs all results to one of three relational tables and 1 ASCII file (see Figure 5.11). The structure and content of each of the relational tables is outlined below.

11.3.1 The SETUP file

The SETUP file (Table A11.1) is used to record and read input choices specified by the user, including appropriate constants and coefficients for the evapo-transpiration and snowmelt equations and names assigned by the user to the main data input files. It is the first file read during execution of the program.

The SETUP file permits user selected names to be assigned to each of the files containing meteorological data, grid data, soil data and pond connectivity data required by the model. It also permits the user to identify the minimum time step increment (1 hour to 24 hours), the Julian day on which to stop operation of the model (ENDAT), the DOS sub-directory into which output data is to be placed (PATH) and which of the five pre-computed estimates of potential evaporation to use when running the main model. Fields 11-17 are used to set user selected values for initial conditions or parameter values for the snowmelt equations run as a preprocessing step to the main model. Fields 18-28 contain user supplied constants and coefficients required for operation of the various evapo-transpiration equations adapted from the model SWATRE. The evaporation equations are run separately as a preprocessing step to operation of the main DISTHMOD model. When run, the evaporation sub-model reads the SETUP file to determine what value to use for each of the constants and coefficients required for the various equations.

11.3.2 The METDATA file

The METDATA file (Table A11.2) contains all of the meteorological input data required for running the main DISTHMOD model and its component sub-models. Fields 1-4 record the month, data, Julian day and hour for each hourly time step. Fields 5-12 contain hourly meteorological data recorded directly at the site or estimated from direct measurements. These include hourly measured precipitation (rainfall in mm), global radiation (W m^{-2}), air temperature (°C), relative humidity (fraction), wind speed (m sec^{-1}) and cloud cover (fraction). These data were used in equations for estimating the hourly snowmelt and potential evaporation. Fields 13-15 record hourly soil temperature data measured at three depths (0-15, 15-40 and 40-60 cm) at a single monitoring site. These data were used to determine whether to treat a given soil layer as frozen for any given time step. Field 16 contains an estimated surface albedo for use in the evapo-transpiration equations. This estimate was computed as a by-product of the snow melt sub-model and was stored in the data base for use with the evaporation sub-model. Fields 17-21 contain the estimates of potential evapo-transpiration (mm hr^{-1}) produced by each of the five (5) equations adapted from the model SWATRE. Fields 22-32 are used by the snowmelt sub-model as locations for temporary storage of intermediate calculations of values in the energy balance equation in each pass through the data set. Field 33 is a logical variable set up to record if any snowmelt was computed for any of the defined "reference depths" for a given hourly time step. Fields 34-49 record the volume of meltwater (if any) produced at a given hourly time step for a hypothetical cell with an initial "reference depth" of snow ranging from 5 cm (MV5) to 200 cm (MV200). These reference depths were arbitrarily selected to encompass the maximum expected range of snow depth for springtime snowmelt in the region and location of interest. Field 50 contains a number that indicates whether any output is required for a given time step, and if so what form it should take.

11.3.3 The GRIDDATA file

The GRIDDATA file (Table A11.3) contains the topographical, topological, soil and moisture status information pertaining to each grid cell. The topographical information consists of the location (row, column) and elevation for each grid cell (fields 1-3). All data concerned with the flow of water between grid elements or the accumulation of water in depressions is here termed topological data. Used in this sense, topology pertains to the hydrological connectivity or spatial relationships between grid elements. The primary topological attributes are the local direction of flow (DDIR), the upslope area count (UPSLOPE) and the ID number of the watershed in which the element is located (SHEDNO). These are calculated using the **Watersh** utilities and imported into fields 4, 7 and 6 of the relational data table. The secondary topological attributes include the record number of the downslope neighbour to which a given cell drains (DREC), the sequential order based on pour elevation (highest to lowest) in which the watersheds are to be processed (SHEDORD) and the volume of ponded water required to first flood any given grid cell (FLODVOL). These data were computed using specially written preprocessing routines external to the model DISTHMOD.

Field 11 (PAREA) records the surface area of the pond at the point at which each grid cell is first inundated. This variable was computed as a by-product of the preprocessing routine that computed the variable FLODVOL. It was not used in the model DISTHMOD but was retained to provide a data set for examining area-volume-depth relationships for potential ponds at the site.

Fields 11, 12 and 13 record data pertaining to the status and depth of ponding for each grid cell in each time step of the model DISTHMOD. PONDELEV records the computed elevation of ponding for all grid cells in a given watershed in the current time step. If the grid cell is not inundated the current PONDELEV is set to equal the recorded grid ELEV. PONDEP is the depth of ponding at the grid cell computed as PONDELEV - ELEV. POND is a logical variable (T/F) which records whether a given cell is inundated during the current time step.

The DISTHMOD model determines whether a grid cell is inundated at any given time by comparing the total volume of water recorded in the PONDATA table as being in the pond associated with the current cell with the fixed statistic FLODVOL pre-computed for each grid cell. If the volume of water currently in the pond (TOTALVOL = VOLINPIT + PREVOL in the database PONDATA) exceeds the volume of water pre-computed as required to first inundate the current cell (FLODVOL) then the current grid cell is deemed to be flooded and the logical variable POND is set to true. Since the program DISTHMOD processes grid cells by watershed, by elevation from highest to lowest, the first cell encountered in any watershed in which TOTALVOL ≥ FLODVOL determines the maximum elevation of ponding (PONDELEV) for that watershed in that time step. All other cells in the current watershed processed after this initial flooded cell are of lower elevation and must also be inundated. The program makes use of this knowledge to automatically label all lower cells as flooded and to assign to all of them the maximum pond elevation (PONDELEV) computed for the first inundated cell.

Fields 15 and 16 record data pertaining to the conceptualised surface detention store (S0). SURFH20 stores a value for the amount of water in the surface detention store (S0) at the beginning and end of each time step. The amount is increased by runoff from upslope cells at the beginning of each time step. It is reduced by infiltration and evaporation during each time step. It is further reduced at the end of each time step by runoff of any volume of water in S0 (SURFH20) in excess of the maximum depth of storage (MAXDEP) assigned to each grid cell. MAXDEP is conceptually equivalent to the surface roughness associated with furrows or ridges.

Field 17 records the initial depth of snow (SNOWDEP0) assigned to or estimated for each grid cell. The model DISTHMOD consults this field for any time step in which the field SMELT in the METDATA file indicates that snow melt was computed for any of the "reference elevations". The initial snow depth of the cell (SNOWDEP0) is read and the estimated values of snowmelt computed for the two reference depths which bracket this actual depth are determined. If either of the bracketing values are positive then a volume of input from snow melt is computed by interpolating between the two reference values to determine an estimate for a cell with a depth equal to the assigned initial depth of snow at the cell.

Fields 18, 19 and 20 record the total moisture content of the soil (mm) at the beginning and end of the current time step for each of the three conceptual soil stores (S1, S2, S3) for each grid cell. DISTHMOD processes stores in the order S3>S2>S1 such that drainage occurs from store S3 before any drainage occurs from S2 into S3 or from S1 into S2. Infiltration from S0 into S1 is computed after all drainage from S1 into S2 has been calculated. Evaporation reduces the water content of S1 once all open surface water in subsuming ponds or in S0 has been removed. The final moisture content of each of the stores at the end of each time step reflects a new water balance altered by infiltration, drainage, runoff and evaporation.

Field 21 (SOIL) contains an integer code identifying the soil type recorded for each grid element. This, in turn, acts as a pointer to the related SOILFILE data file which contains data on the hydraulic properties of each soil type.

The data for each grid cell is stored in the GRIDDATA relational table in the format row, column, z_1, z_2, z_3, ...z_n rather than being maintained as a series of N independent (n x m) matrices. In this way, all data pertaining to a given grid cell is available for immediate access once the record for that grid cell is located in the database. Thus, reading one record of data from the relational table is equivalent to doing an N-layer overlay of N matrices for a given grid cell. Theoretically, the relational table approach permits the data set to be unconstrained in size. Any number of grid cells may be defined and any number of parameters or variables considered for each grid cell. The only serious limitation is the time constraint imposed by the requirement to continually read and write data to and from disk storage as each record is processed. This delay can be minimized during execution of the model by creating a virtual disk in RAM and reading the GRIDDATA file onto this disk.

11.3.4 The SOILDATA file

The SOILDATA FILE (Table 11.4) contains information on the hydraulic properties of the various soil types defined for the area. It is used as a lookup table to relate soil type codes stored for each grid cell in the GRIDDATA file to their respective soil properties. Any number of soil types having different hydraulic properties may be defined and stored in the SOILDATA table. A numerical pointer is used to establish a relation between the SOIL field of the GRIDDATA table and the corresponding SOIL field of the SOILDATA table.

Fields 2-14 record data on the hydraulic properties of store S1. Bulk density (BD1) was assigned based on either field measured values or values stored in the Alberta Soil Layer File (SLF) for each soil series. SLF data were used in cases where the field measured values were considered suspicious. PD1 records an assumed particle density for the soil materials making up the S1 store. MINPER1 and MAXPER1 record the upper and lower values for the range of permeability measured for the S1 store of each soil series. These values were used to arrive at an estimate for the ANSWERS parameters final infiltration capacity (FC) and A, the difference between the maximum and steady state rates as per instructions on page 36 of the ANSWERS manual (Beasley and Huggins, 1981). Fields 7-9 contain estimates of the total porosity (TP1), the moisture content at field capacity (FP1) and the moisture content at wilting point (WP1) of store S1 expressed as percent volumetric moisture. When these fields are multiplied by the thickness of the store (mm) the result is an estimate of the total volume of water stored in S1 at saturation (VolTP1), at field capacity (VolFP1) and at wilting point (VolWP1). Gravitational water capacity (GWC1) is computed as total porosity (VolTP1) minus field capacity (VolFP1). It represents the volume of water that can drain from the control depth (S1) solely under the influence of gravity (ie down to field capacity).

Fields 15-25 and 26-36 repeat the content of fields 2-14 except that data apply to stores S2 and S3 respectively instead of store S1. There is no estimate of wilting point (WP) for either of stores S2 or S3. In DISTHMOD, the moisture content of S1 can be reduced to the wilting point (WP1) through evaporation but evaporation does not operate on stores S2 or S3. The minimum water content to which stores S2 and S3 can be reduced through gravitational drainage is therefore considered to be equivalent to their respective field capacities (FP2 & FP3). Field 37 contains a value for the ANSWERS infiltration exponent (P) which relates the rate of decrease of infiltration capacity to increasing moisture content. Fields 39 and 40 contain data on the ANSWERS parameters roughness height (HU) and roughness coefficient (RC) used to estimate maximum surface detention (MAXDEP in the GRIDDATA file).

11.3.5 The PONDDATA file

The PONDDATA file (Table 11.5) contains statistics that describe watershed areas, the depressions associated with each watershed and the connectivity between watersheds. Most of these statistics pertain to geomorphological attributes of the watershed and were computed once during a pre-processing operation (see Chapter 4). Geomorphological attributes include the ID. number (SHEDNO) and area of the watershed (SHEDAREA), the total volume (TOTALVOL) and area (PITAREA) of the associated depression when full, the incremental increase in volume required to flood 'higher order" ponds (VOLTOFLOOD), the location (PITROW, PITCOL) and elevation (PITELEV) of the depression centre and the location and elevation of the grid cells at which drainage (or overspill) takes place from the watershed in question (INROW, INCOL) into its neighbouring watershed (OUTROW, OUTCOL). Field 28 (ORDER) contains a number indicating the sequence in which the current watershed will be processed by the model DISTHMOD. The sequence number is assigned so as to ensure that watersheds are processed in order beginning with the watershed with the highest overspill elevation (POURELEV) and progressing to the watershed with the lowest pour elevation.

Field 8 (DRAINSTO) identifies the number of the neighboring watershed into which the current pond is most likely to drain. Field 19 (NEXTPIT) identifies a second watershed into which the current pond may drain at location ROW2, COL2 at the same pour elevation. Fields 23 (POUREC) and 32 (POUREC2) contain the GRIDDATA file data base record numbers of records containing data pertaining to the watersheds identified by DRAINSTO and NEXTPIT respectively. These record numbers act as pointers that allow the program to jump from one record to another specific record without having to search the database for a record meeting specified conditions.

A few statistics in the PONDDATA table pertain to dynamic attributes whose status changes during the operation of the model DISTHMOD and whose values are updated in the PONDDATA table after any change. The field VOLINPIT records the volume of water stored in the identified depression at the end of any given time step. The field FULL contains a logical variable (T/F) that is reset according to whether the current pit is considered to be full or not full.

The field VISITED contains a logical variable that is always initially false but is set to true once any particular record is processed in any given time step. If the sequence of pointers causes the model DISTHMOD to return to a pond record that it has already consulted then the current pointers define a circular loop in which the starting pond overspills into its neighbour or neighbours which ultimately overspill back into the starting pond. This is indicative of a "nested depression" situation in which all of the ponds at the lower level are full. It is necessary to recognize this and to select a second pointer from the field NEXTPIT that points up into a "higher order" subsuming depression. This value directs flow into the higher order subsuming depression. If the program encounters a record for which the logical variable VISITED is true it knows that it has returned to a record it has previously processed and that the value in the pointer NEXTPIT must be used to escape from the circular loop.

11.3.6 Output files

The types of output produced by DISTHMOD and the dates and times for which output is prepared are selected by assigning a numerical code of 1-5 to the field OUT for one of the hourly records in the METDATA file. Any value greater than zero (0) causes DISTHMOD to produce the specified output for the specified hour and day. For the present exercise, output was selected to coincide with the dates on which field surveys of pond location, extent and depth had been carried out. The values 1-5 specify 5 different combinations of three kinds of output.

A value of one (1) tells DISTHMOD to output an ASCII file of values for depth of ponding for all grid cells for the specified day and hour. This ASCII file is easily reformatted to produce a grid map for display of the extent and depth of ponding. The grid map can be used to compare simulated extent and depth of ponding with that actually observed in the field for the equivalent date. The output file produced for each specified date is given a name which incorporates the day number of the Julian day for which output was requested. The file is always named POND+(JULIAN DAY NO).TXT (i.e. POND94.txt). This facilitates identifying which pond map file is associated with which output date.

A value of 2 causes DISTHMOD to write out a duplicate copy of the current PONDATA dBase III+® file. This file is given the name PONDS+(JULIAN DAY NO).dbf. The significant information contained in this file includes the values stored in the fields

VOLINPIT, FULL, PITUP and TOTALVOL. This information details, for each pond, whether it is currently computed to be FULL and, if so, to which pour point location or subsuming depression overspill is currently being directed. Consultation of the fields VOLINPIT and TOTALVOL can reveal the extent to which partially full ponds are full. These output data can be compared with data on actual pond location, size, area and volume collected on each of the field survey dates.

A value of 3 causes DISTHMOD to write out a portion of the current GRIDDATA file consisting of the fields ROW, COL, SURFH20, S1THETA, S2THETA, S3THETA and PONDEP to a dBase III+® file named SOIL+(JULIAN DAY NO).dbf. This file provides a snapshot of the computed moisture content for each of the conceptual stores in the model for each of the grid cells. It also repeats the information on PONDEP that is written to an ASCII file under choice 1. This data can be used to produce maps portraying the distribution of estimated soil moisture for all "stores" for all grid cells.

A value of 4 causes DISTHMOD to produce both the SOIL**.dbf and the PONDS**.dbf files described above. A value of 5 causes all three forms of output to be produced.

In all cases, a database file named FLOW89.dbf is produced which records the volume of runoff (mm) escaping from any watershed that drains to the edge of the data matrix for any hourly time step and day for which overspill is computed to occur.

11.4 Programming overview

A modular approach has been adopted for the DISTHMOD model. The main program simply provides a framework for calling independent subroutines (called procedures in dBase III+® syntax) for simulating the individual component processes. As with other models from which DISTHMOD draws heavily (c.f. ANSWERS, Beasley and Huggins, 1981) the algorithms or equations used to represent any of the individual components may be altered or substituted without adversely affecting any of the other components. Provision has also been made to selectively "turn off" or "turn on" the computations for individual component relationships. For example, turning off the procedure for computing infiltration effectively simulates a situation of zero infiltration.

The distributed approach adopted for DISTHMOD uses data produced by the **Watersh** utilities to determine the order in which grid cells are processed. Processing is by catchment area starting from the catchment area with the highest overspill elevation and working down to the lowest. Within each catchment, grid elements are processed along flow paths, in order, from the highest elevation to the lowest (ie the pit centre). In this way the correct order in which each grid cell delivers runoff to its downslope neighbor is maintained. In any given time step, the water balance for all upslope stores will have been computed and the excess water available for runoff determined before any given cell is processed.

An important difference between DISTHMOD and other distributed models occurs at the point when the last, or lowest, cell in any given catchment is processed. This cell must be either a pit centre or an edge cell draining to the 'outside world'. If it is a pit centre, a pond filling/emptying procedure is invoked. The procedure allows ponds to either a) fill; in which case they may either overspill or coalesce with adjacent ponds at the same elevation, or b) to empty; in which case they may bifurcate if the neighbour pond is at the same elevation, or break links with any lower, downslope catchment.

The pond change procedures make use of a relational database table containing certain useful 'pond statistics'. These include the volume of water currently in the pit, the maximum volumetric capacity of the pit, the identity of the watershed into which the pit will drain once full and the location of the 'pour point' at which water overspilling from the pond will enter the downstream catchment. The table also contains 'pointers' that indicate whether a pond is currently full and, if so, into which pit or watershed it is currently delivering its excess water. Using the pointers, it is possible to traverse through the pond data table to identify the location of the pond or pour point where excess runoff should be placed, or, in the case of net pond losses, the correct pond from which to reduce the recorded stored volume.

The various procedures and the sequence in which they are called are as follows:

The BANNER procedure produces a screen template identifying the program and listing headings for the various kinds of information about program variables and execution status that are displayed to the screen during execution of the program.

The READMET procedure is used to extract the meteorological data on inputs from rainfall and snowmelt and losses from evaporation. The procedure reads values for hourly rainfall, snowmelt and potential evaporation from a file of previously recorded or estimated data (METDATA). Other data read include the soil temperature at each of the three control depths, an integer indicating what type of output, if any, is requested for that time step, and a logical variable that indicates if any snowmelt has been computed for that time step for any initial depth of snow. If selected, an option exists that will read and sum the data for an interval of up to 24 one hour time steps provided that there is no rainfall or snowmelt over that interval, the soil temperature doesn't change from below to above zero for any of the soil layers and no output has been requested for any of the time steps included in the interval. Summing data for several time steps dramatically reduces the amount of processing and the time required to run the model to completion as each time step skipped saves computation of water balance and runoff equations for all grid elements.

The METSTAT procedure called at the completion of each READMET procedure is used to display the meteorological data for the current time step(s) to the screen.

The RESET procedure switches the active (or selected) data base to the grid cell data base (GRIDDATA) and resets several temporary memory variables to their default values.

The READGRID procedure is invoked every time the model moves on to process a new grid cell. It reads the data about each grid element required for subsequent procedures that estimate snowmelt, ponding, infiltration, evaporation and runoff. The data read include the initial depth of snow for that grid element (SNOWDEP0), the volume of water at which it would first be flooded (FLODVOL), the number of the watershed in which the grid element is located (SHEDNO), the actual amount of water stored in surface retention for the element (SURFH2O), the maximum potential surface retention volume (MAXDEP), and the current antecedent moisture content of the infiltration store (S1THETA). A code for the soil type assigned to that grid cell is read and used to look up, in a related SOILDATA file, values for total porosity (TP1), steady state infiltration capacity (FC1), gravitational water capacity (GWC1) and wilting point WP1 for the given soil type.

Every time READGRID is executed, the watershed number of the current grid is checked against the number of the watershed assigned to the last processed grid cell. This permits identification of whether the current cell belongs to the last watershed processed or whether processing has begun on a new watershed. If it is determined that the present cell belongs to a new watershed, the program executes a special set of instructions. These instructions follow pointers in the PONDDATA file to determine the identity of the highest level depression currently flooding the watershed to which the cell belongs and to read the volume of water recorded as currently stored in this depression. This volume is compared with the volume required to flood the cell (FLODVOL) to determine whether the cell in question is currently flooded by ponding or is not. This comparision is repeated for every new grid cell in the current watershed until the watershed changes or a cell is encountered which has a volume-to-flood (FLODVOL) less than or equal to the volume of water recorded as currently stored in the depression. This cell is considered to be flooded as are all subsequent cells which are of equal or lower elevation.

The SHEDSTAT procedure is run each time a new watershed is identified during the READGRID procedure. It displays to the screen the number of the new watershed and a variety of its attributes including the number of any higher order depression subsuming the original depression, the total storage volume of the highest order depression and the present volume of water stored in the depression. The estimated completion status of the program is also updated each time SHEDSTAT is invoked. Current status is given in terms of the proportion of total time steps that have been processed up to the current time and the proportion of grid cells that have been processed in the current pass through the grid cell data base. Expected completion is estimated by relating the time taken to complete the number of time steps processed up to the current time to the number of steps remaining to be processed. The status screen is provided because the program can take many hours to run for large data sets and some idea of current status and completion time was considered desireable.

THE GRIDSTAT procedure updates the screen with several attributes of the grid cell for every new grid cell processed. These include the volume of water required to flood the cell, the estimate of maximum surface retention for the cell and the volume of water estimated to be stored in surface retention in the cell, if any.

The SNOWMELT procedure is used to estimate the volume of water released by snowmelt on a given grid element during any given time period. The procedure determines which two previously computed reference depths bracket the initial snow depth (SNOWDEP0) recorded for the element. The volume of potential snowmelt produced during the current time step from initial snow depths corresponding to the two reference depths is read and a linear interpolation is performed to estimate the amount of melt likely to be produced by a snow pack of initial depth H intermediate between the two reference depths. This interpolated value is used as the estimate of actual snowmelt volume released onto the grid element during the current time step.

The INFILT procedure estimates the amount of water that infiltrates into the surface soil during any given time period. It is based upon the ANSWERS equations for drainage and infiltration. Processing occurs in two stages.

In the first stage, drainage is estimated for redistribution of soil water from upper to lower layers in the soil. The soil is conceptualised as composed of three subsurface stores (S1 - S3) for each grid element and a fourth saturated zone store for the entire watershed (S4). Drainage is estimated from each store into its underlying store in the order S3 -> S4 (procedure S3DRAIN) , S2 -> S3 (procedure S2DRAIN) then S1 -> S2 (procedure S1DRAIN). The rate of drainage from any store is set to zero if the soil in the store is deemed to be frozen (soil temperature is below 0 °C) or if the moisture content of the store falls below a threshold value taken to approximate field capacity. Otherwise, drainage rate is estimated as a function of the current moisture content of the store and decreases as the soil dries out. The actual amount of water transferred from a higher to a lower store in a given time step may be limited by the amount of room available in the lower store. If there is insufficient space in the lower store to accommodate all of the potential drainage, only as much water will drain as there is room to accommodate.

The second stage is undertaken after drainage has been estimated for all 3 levels of soil store and the moisture content and amount of space available in the topmost infiltration store (S1) has been determined. Processing proceeds differently depending upon whether the cell being processed is judged to be inundated by water from a pond or to be above the elevation affected by ponding at a particular time.

If a cell is deemed to be flooded by ponded water, then the volume of water available to infiltrate into the cell is computed as the total of all runoff arriving at the cell plus all water stored in the pond in excess of the volume of water required to flood the selected cell. If the volume of water available for infiltration is sufficient to satisfy all infiltration demand, then that volume of water is removed from storage in the pond and placed into storage in store S1 of the soil. If the volume of water available from the pond for infiltration is less than the infiltration demand, then all of the available pond water is allowed to infiltrate, the volume of the pond is reduced accordingly, and the procedure SOILINFT is called to allow the remaining infiltration demand to be satisfied by any runoff water held in surface retention.

If the current cell is not estimated to be affected by macro-ponding, infiltration into the topmost store takes place at a potential infiltration rate estimated according to the Holtan

(1961) equation as implemented in the ANSWERS model (Beasley and Huggins, 1981). The ANSWERS implementation divides infiltration into two fractions, one consisting of infiltration in troughs under saturated conditions arising from micro-ponding and the other consisting of direct infiltration of rainfall into the soil on ridges rising above any micro-ponding. This division of infiltration is maintained in the implementation adopted for DISTHMOD (procedure SOILINFT). If the amount of water on the surface available for infiltration is less than the estimated rate of infiltration or if the amount of space in the infiltration store is insufficient to accommodate all of the potential infiltration, the actual amount of infiltration may be lower than the potential rate. In such cases, the actual infiltration is equal to the volume of water on the surface or the amount of space available respectively.

Any time the moisture content of a soil store is estimated to change, the new moisture content is displayed to the status screen via one of tthe display procedures S1STAT, S2STAT or S3STAT. Any time infiltration in a cell inundated by macro-ponding results in a change in the volume of water stored in the pond, the screen is updated to display the new pond volume via the procedure PONDSTAT.

The EVAP procedure is used to estimate the amount of actual evaporation from open water ponded on the surface. The procedure SOILEVAP is used to remove water from the surface soil store (S1) if all potential evaporation is not satiisfied by evaporation from ponded water. The potential evaporation is precomputed for each time step and stored in the METDATA file. Evaporation is first allowed to occur at full potential from any open surface water stored as ponding in macro-scale depressions. In the procedure EVAP, if the amount of ponded water overlying a given grid cell exceeds the amount required to satisfy potential evaporation then all potential evaporation is used up in evaporating water from the surface of the pond. If the potential evaporation exceeds the available supply of ponded surface water then all available surface water is removed from the pond and the remaining potential evaporation is used to remove water from the soil via the procedure SOILEVAP. In SOILEVAP, water stored as as surface retention in micro-depressions is first removed at full potential up to a maximum determined by the potential evaporation. If there is insufficient water in surface retention to satisfy the potential evaporation, any remaining evaporative demand is satisfied by removing water from the soil. The volume of water removed from the soil is a function of the rate at which water is computed to be able to move through the soil of store S1. If water can move through the soil at a rate in excess of the rate of potential evaporation then actual evaporation occurs at the full potential rate. If the rate of water movement through the soil is less than the potential rate of evaporation, then the actual rate of evaporation equals the lower rate of movement of water through the soil. The rate of movement of water through the soil is adjusted as a function of actual soil moisture content and is set to zero whenever the soil is frozen or the soil moisture content is less than or equal to the wilting point of the soil.

The FLOWDOWN procedure is invoked whenever the amount of water stored in micro-depressions on the surface exceeds the value assigned for surface retention. It simply passes the excess volume of water from the current cell to its designated downslope neighbour with no delay or lag.

The PONDVOL procedure is called each time a pit centre is processed. It checks to see if there has been any addition (by runoff) or removal (by evaporation or infiltration) of water from the pond in the current time step. If there has been a net loss of water, the procedure PONDLOWER is called to remove that volume of water from the appropriate record in the pond database. In PONDLOWER, if the volume of any higher order pond is reduced to zero, then the procedure locates the appropriate underlying lower order pond and extracts the remainder of the loss of volume from that pond. In a similar fashion, if additions to a pond raise it to its maximum volume, then the procedure PONDADD determines if there is a higher order subsuming depression and allocates the remaining volume of water to it. If there is no higher order depression, then any excess is placed at the overflow or pour point grid cell. The PONDVOL procedure is able to account for removals or additions of water into or from a complex hierarchy of depressions. It is quite unique and represents one of the main original contributions of the present research.

If the volume of water stored in a pond is changed via either PONDADD or PONDLOWER, then the screen display is updated with the new pond volume via the procedure PONDSTAT.

The OUTPUT procedure is invoked for any hourly time step for which output has been requested. It produces one or more kinds of output from a selection of a) a grid map of depth of ponding, b) a database of pond volume data or c) a database of soil moisture status data for every one of the study area grid cells. Any combination of output reports can be requested for any hourly time step.

11.5 Summary of DISTHMOD characteristics

The DISTHMOD model has the following characteristics:

a) each grid cell is conceptualised as composed of four separate stores; an interception store (S0) an infiltration store (S1), an unsaturated soil zone store (S2) and a saturated soil zone store (S3).
b) a water balance is computed for each store at each grid cell. The water balance takes into account infiltration into the soil, losses to the saturated zone and losses from the upper store to evapo-transpiration. Any residual water is available for runoff from the grid to its down-slope neighbour.
c) each catchment area is treated as a cascade of grid cell reservoirs. Grid cells are processed from the highest downwards along flow paths defined for each catchment. Excess water available for runoff in any grid cell is passed to its down-slope neighbour and the water is allowed to cascade down-slope.
d) in each time step, water in all grids is capable of being delivered to the pit centre if it is not lost by evapo-transpiration or delayed by infiltration along the way.
e) in each time step, the last cell processed in each watershed is a pit cell. When each pit cell is encountered, a procedure is invoked to check if there has been any increase or decrease in pond volume in the current time step. If there has been a change in volume, the appropriate amount of water is added to or removed from the appropriate database records of pond volume.
f) at the end of each time step, the amount of water stored in each depression reflects the current volume. This is used to check if any given cell can be assumed to be inundated during the next time step.

DISTHMOD permits explicit calculation of water balances at every grid location in a simplified manner that is feasible for operational use where both data availability and processing time are constraints. It does not attempt to be as comprehensive as other, more rigorous, physically based, distributed models but it may be more appropriate for some applications. It does allow for a crude approximation to be made of likely losses and delays arising from evaporation and infiltration as runoff traverses flow paths to depressional centres. It is unique in its ability to account for flow into depressions and overflow or coalescence of ponds. Almost all other distributed models start with the assumption of completely integrated drainage and do not address depressional storage.

11.6 DISTHMOD program listing

```
***********************************************************
* PROGRAM DISTHMOD.PRG
***********************************************************
* This program is intended to effect a distributed model of surface water
* runoff and ponding in a pitted, non-integrated agricultural landscape.
* It computes an estimate for surface water runoff based on a simple water
* balance model. The conceptual equation for the water balance model is:
* RUNOFF=RAIN + SNOWMELT + INFLOW - EVAPORATION
* - INFILTRATION - DETENTION
* Each of the components of the runoff model is read or computed in a
* simple manner for each grid cell of an n-row by m-column array of data
* points (from a DEM of the same size) for each time step. The normal and
* recommended timestep is 1 hour.
***********************************************************

CLEAR ALL
SET TALK OFF
SET ECHO OFF
SET SCOREBOARD OFF
SET DECIMAL TO 15
CLEAR

* Declare and initialize all variables here (for the present all variables
* will be PUBLIC variables common to all procedures called by the main
* program). It may save space and time to redefine any variables used only
* locally in a single procedure as PRIVATE variables. This will be done at
* some later date if it seems likely to make the program more efficient

DECLARE PIT[50]    && sets up an array for tracking path through pits
DECLARE POND[15]
ACTINFT  = 0.0
ANS      = .F.
C        = 3
CURRENT  = 1
DeltaT   = 0
DOTSTRING = ""
DR1      = 0
DR2      = 0
DR3      = 0
DR4      = 0
ELAPSED  = 0
ERATE1   = 0.0
EVAPHRS  = 0
EVAPVOL  = 0.0
EVCHOICE = "PENMAN"
FH       = 0.0
FILLDIFF = 0.0
FIRSTIME = 0
FLODELEV = 730.0
FLOODVOL = 0.0
FMAX     = 0.0
FRAME = CHR(201) + CHR(205) + CHR(187) + CHR(186) + ;
```

```
        CHR(188) + CHR(205) + CHR(200) + CHR(186) + ;
        CHR(32)
 FROZEN1   = .T.
 FROZEN2   = .T.
 FROZEN3   = .T.
 FWA       = 0.0
 GRIDPCT   = 0
 HREVAP    = 0.0
 HU        = 0.0
 INI1      = 0.0
 INI2      = 0.0
 INI3      = 0.0
 INFLUX1   = 0.0
 LASTSHED  = 0
 LASTVAL   = 0.0
 LASTDAY   = 100
 LASTIME   = 0
 MAINFILE  = " "
 MAXDEPTH  = 0.0
 MAXGRIDS  = 22400
 MAXFLOOD  = 30000.0
 MAXPOUR   = 0.0
 MELTING   = .F.
 MELT50    = 0.0
 MELT100   = 0.0
 MELT150   = 0.0
 MELT200   = 0.0
 MELT250   = 0.0
 MELT300   = 0.0
 MELT400   = 0.0
 MELT500   = 0.0
 MELT600   = 0.0
 MELT700   = 0.0
 MELT800   = 0.0
 MELT900   = 0.0
 MELT1000  = 0.0
 MELT1250  = 0.0
 MELT1500  = 0.0
 MELT1750  = 0.0
 MELT2000  = 0.0
 MELTVOL   = 0.0
 METEOFILE = " "
 METPCT    = 0
 METREC    = 1
 MA        = 0.0
 MP        = 0.0
 MGWC1     = 0.0
 MGWC2     = 0.0
 MGWC3     = 0.0
 MK1SAT    = 0.0
 MK2SAT    = 0.0
 MK3SAT    = 0.0
 MS1MIN    = 0.0
 MS2MIN    = 0.0
 MS3MIN    = 0.0
```

```
MS3NEW    = 0.0
MS1THETA  = 0.0
MS2THETA  = 0.0
MS3THETA  = 0.0
MS1SAT    = 0.0
MS2SAT    = 0.0
MS3SAT    = 0.0
MS4SAT    = 0.0  && Not currently used
MS1WP     = 0.0
N         = 0
NEWPOND   = 0.0
NEWTIME   = 0
NEWSHED   = .T.
NEXTCELL  = 1
NUMGRIDS  = 1
OUTCHOICE = 0
OUTMAP    = "POND1.IMG"
OUTPOND   = "PONDS1"
OUTSOIL   = "SOILS1"
PITCENTRE = .F.
PITFILE   = " "
PONDED    = .F.
PONDLOSS  = 0.0
POTEVAP   = 0.0
PPT       = 0.0
PRESVOL   = 0.0
PRES_TIME = 0
PROBLEM   = "None"
R         = 2
RAIN      = 0.0
RETAINED  = 0.0
RIDGEPPT  = 0.0
ROUGH     = 0.0
RUNOFF    = 0.0
SATSTORE  = 0.0      && Not used at present
SOILSFILE = "        "
SOILTEMP1 = 0
SOILTEMP2 = 0
SOILTEMP3 = 0
S1DELTA   = 0.0
S2DELTA   = 0.0
S3DELTA   = 0.0
S1ROOM    = 0.0
S2ROOM    = 0.0
S3ROOM    = 0.0
SD0       = 0.0
SPILLSTO  = 0
STARTIME  = TIME()
STARTPOUR = 0.0
STARTPIT  = 0
SURFVOL   = 0.0
THISEVAP  = 0.0
THISHED   = 0
THISHOUR  = 0
TODAY     = 0
```

```
TOP_PIT  = 1
TOTALMET = 0
TOTVOL   = 0.0
TROFPPT  = 0.0
UPLOSS   = 0.0
X        = 0

USE SETUP
GO TOP
MAINFILE  = LTRIM(TRIM(GRIDFILE))
METEOFILE = "C:\MODEL\"+LTRIM(TRIM(METFILE))
SOILSFILE = LTRIM(TRIM(SOILFILE))
PITFILE   = LTRIM(TRIM(PONDFILE))
FLOFILE   = "C:\MODEL\"+LTRIM(TRIM(FLOWFILE))
OUTPATH   = LTRIM(TRIM(PATH))
EVCHOICE  = LTRIM(TRIM(EVAPTYPE))
DR4       = K4SAT
LASTDAY   = ENDAT

DO ZEROARRAY

SELECT C
USE &SOILSFILE ALIAS SOILDAT
INDEX ON SOIL TO SOIL
SET INDEX TO SOIL
SELECT A
USE &MAINFILE INDEX TOPDOWN ALIAS GRIDAT
SELECT B
USE &METEOFILE ALIAS METDAT
SELECT D
USE &PITFILE ALIAS PONDAT
SELECT E
USE &FLOFILE ALIAS FLOWDAT
SET SAFETY OFF
ZAP
SET SAFETY ON

************************************************************

SELECT METDAT
TODAY = JULIAN
DO BANNER

DO WHILE TODAY <= LASTDAY .AND. .NOT. EOF()
*                       && Start of loop through METDAT file (ie ALLMET89)
 DO READMET             && Reads & SUMS met data for 1-24 hourS into memory
 DO RESET               && Resets active data base to A = GRIDAT
* also resets number of the temporary memory variables to starting values
 DO WHILE .NOT. EOF()
  IF NOABORT()
* ie start of loop through DEM MAIN data file (GRIDAT = LUNTY1.dbf)
    DO READGRID         && Reads into mem vars data for this grid cell
    IF MELTING          && Melting is logical variable read from METDAT
       DO SNOWMELT      && Procedure to compute expected snowmelt given
* initial starting depth of snow for this grid cell vs estimated melt
```

```
    ELSE
        MELTVOL = 0.0
    ENDIF
    @ 17, 17 SAY MELTVOL  PICTURE "###.##"
* May not want to write the data below to disk every time for every pass
* through the data set. Might want to save it only when output is wanted.
    IF OUTCHOICE > 0.0
        IF PONDED
         REPLACE PONDELEV WITH FLODELEV
         REPLACE PONDEP WITH (FLODELEV - ELEV)+0.1
        ELSE && (ie if PONDED IS NOT TRUE)
         REPLACE PONDELEV WITH ELEV
         REPLACE PONDEP WITH 0.0
        ENDIF
    ENDIF
    SURFVOL = RAIN + MELTVOL + RETAINED
    IF .NOT. FROZEN1
        DO INFILT
    ENDIF
    IF POTEVAP > 0.0
        DO EVAP
    ENDIF
    IF .NOT. PITCENTRE
        DO CASE
         CASE SURFVOL = RETAINED
         && Do nothing as there has been no change in surface vol
         CASE  SURFVOL > MAXDEPTH && Runoff will occur after MAXDEP full
          RUNOFF = SURFVOL - MAXDEPTH
          REPLACE SURFH20 WITH MAXDEPTH
          DO FLOWDOWN
         CASE SURFVOL <= 0.0     && Traps negative values of SURFVOL
          REPLACE SURFH20 WITH 0.0
         OTHERWISE  && SURFVOL > 0 BUT < MAXDEP -> Fills SURFH20
          REPLACE SURFH20 WITH SURFVOL
        ENDCASE
    ELSE  && ie IF PITCENTRE IS .T.
        DO CASE
         CASE SURFVOL = RETAINED  && There has been no runoff or evap
          && Do nothing
         CASE SURFVOL <= 0.0     && Traps negative values for SURFVOL
          SURFVOL = 0.0
          REPLACE SURFH20 WITH 0.0
         CASE SURFVOL < MAXDEPTH
          REPLACE SURFH20 WITH SURFVOL
          SURFVOL = 0.0
         OTHERWISE  && ie SURFVOL > MAXDEPTH and SURFVOL > 0
          SURFVOL = SURFVOL - MAXDEPTH
          REPLACE SURFH20 WITH MAXDEPTH
        ENDCASE
        DO PONDVOL
        DO PONDSTAT
        SELECT GRIDAT
        SET RELATION TO SOIL INTO C
    ENDIF
    SKIP
```

```
* This bit inserted at a late date to provide a way to abort out of prg
   ELSE
     @ 24, 0 SAY "Program paused, do you wish to abort (Y/N)? : ";
     GET ANS PICTURE "Y"
     READ
     IF ANS
         @ 24, 0 CLEAR
         SELECT METDAT
         GO BOTTOM
         LASTDAY = 0
         EXIT
     ENDIF
   ENDIF
 ENDDO
 SELECT METDAT
 IF OUTCHOICE > 0
   DO OUTPUT
 ENDIF
 SELECT METDAT
ENDDO
@ 24,0 say " Program completed! "
************************************************************
************************************************************
PROCEDURE BANNER
************************************************************
* PURPOSE: To produce a banner and status screen that displays the current
* status and percent completion of the program and estimates projected
* time of completion. This bit only writes the basic banner to the screen

SET COLOR TO W/B,N/R
STORE 1 TO TOP
STORE 0 TO LEFT
STORE 22 TO BOTTOM
STORE 79 TO RIGHT
@ TOP, LEFT, BOTTOM, RIGHT BOX FRAME

* @R,C SAY " Ponding Infiltration Transmission and Storage Modelling of "+;
* "Depressions"
* @R+2, C+8 SAY " DDDD  I  SSSS TTTTT H   H M     M  OOO   DDDD"
* @R+3, C+8 SAY " D   D I S       T   H   H MMM MMM 0   O  D   D"
* @R+4, C+8 SAY " D   D I  SSS    T   HHHHH M  M  M O   O  D   D"
* @R+5, C+8 SAY " D   D I     S   T   H   H M     M O   O  D   D"
* @R+6, C+8 SAY " DDDD  I  SSSS   T   H   H M     M  OOO   DDDD"

@R, C SAY " DISTHMOD: A program to simulate overland flow and ponding "+;
"in depressions"
@R+1, C SAY " Written by: Robert A. Mac Millan              "+;
"Copywrite: January, 1991"

@R+2, C SAY " NOTE: This program can take UP TO 24 hours to run to "+;
"completion on large"
@R+3, C SAY "       Data sets. Information appears below on current "+;
"completion status"

@R+5,  C SAY "GRID DATA: "
```

```
@R+6,  C SAY "Shed Number : "
@R+7,  C SAY "Snow Depth 0: "
@R+8,  C SAY "Vol to Flood: "
@R+9,  C SAY "MaxDepth H20: "
@R+10, C SAY "Retained H20: "
@R+11, C SAY "Time Step hr: "

@R+5,  C+22  SAY "SOIL PROPERTY:    S1      S2      S3"
@R+6,  C+22  SAY "Sat H20      :"
@R+7,  C+22  SAY "Min H20      :"
@R+8,  C+22  SAY "Initial H20  :"
@R+9,  C+22  SAY "Room to fill :"
@R+10, C+22  SAY "Drainage rate:"
@R+11, C+22  SAY "Drainage flux:"
@R+12, C+22  SAY "Soil inf flux:"

@R+12, C+45  SAY "Soil ev flux:"

@R+13, C  SAY "MET DATA: "
@R+14, C  SAY "Present day : "
@R+15, C  SAY "Meltvol (mm): "
@R+16, C  SAY "Rainfall(mm): "
@R+17, C  SAY "PotEvap (mm): "

@R+13, C+22 SAY "PONDATA:"
@R+14, C+22 SAY "Total volume: "
@R+15, C+22 SAY "Present Vol : "
@R+16, C+22 SAY "Pondloss mm : "
@R+17, C+22 SAY "Present pond: "

@R+13, C+45 SAY "DATA ON RATE OF PROGRESS: "
@R+14, C+45 SAY "Time started    : "
@R+15, C+45 SAY "Present time    : "
@R+16, C+45 SAY "Percent thru grid: "
@R+17, C+45 SAY "Percent thru met : "

@R+19, C SAY "0%          25%          50%          75%          100%"

START_TIME = TIME()
@ R+14, 67 SAY LTRIM(START_TIME)

SELECT METDAT
GO BOTTOM
TOTALMET = RECNO()
GO TOP
***********************************************************


***********************************************************
PROCEDURE READMET
***********************************************************

DeltaT   = 0
EVAPHRS   = 0
OUTCHOICE = 0
```

```
RAIN     = PREC
TODAY    = JULIAN
POTEVAP  = 0.0

MELT50   = 0.0
MELT100  = 0.0
MELT150  = 0.0
MELT200  = 0.0
MELT300  = 0.0
MELT400  = 0.0
MELT500  = 0.0
MELT600  = 0.0
MELT700  = 0.0
MELT800  = 0.0
MELT900  = 0.0
MELT1000 = 0.0
MELT1250 = 0.0
MELT1500 = 0.0
MELT1750 = 0.0
MELT2000 = 0.0

IF RAIN = 0.0
 DO WHILE JULIAN = TODAY .AND. PREC = 0.0
  DO GETMET
   SKIP
 ENDDO
ELSE
 DO GETMET
 SKIP
ENDIF
DO METSTAT  && Displays met data stats to the screen once each time step
************************************************************
************************************************************
PROCEDURE GETMET
************************************************************

THISHOUR  = HOUR
METREC    = RECNO()
DeltaT    = DeltaT + 1

IF OUT > 0
 OUTCHOICE = OUT
ENDIF

IF SMELT
 STORE .T. TO MELTING  && Sets logical to .T. if any melting in this hour
ENDIF

MELT50   = MELT50   + MV5
MELT100  = MELT100  + MV10
MELT150  = MELT150  + MV15
MELT200  = MELT200  + MV20
MELT300  = MELT300  + MV30
MELT400  = MELT400  + MV40
MELT500  = MELT500  + MV50
```

```
MELT600  = MELT600  + MV60
MELT700  = MELT700  + MV70
MELT800  = MELT800  + MV80
MELT900  = MELT900  + MV90
MELT1000 = MELT1000 + MV100
MELT1250 = MELT1250 + MV125
MELT1500 = MELT1500 + MV150
MELT1750 = MELT1750 + MV175
MELT2000 = MELT2000 + MV200

SOILTEMP1 = SOILT1
SOILTEMP2 = SOILT2
SOILTEMP3 = SOILT3

IF SOILTEMP1 < 0.01
 STORE .T. TO FROZEN1
ELSE
 STORE .F. TO FROZEN1
ENDIF
IF SOILTEMP2 < 0.01
 STORE .T. TO FROZEN2
ELSE
 STORE .F. TO FROZEN2
ENDIF
IF SOILTEMP3 < 0.01
 STORE .T. TO FROZEN3
ELSE
 STORE .F. TO FROZEN3
ENDIF

HREVAP = &EVCHOICE
IF HREVAP > 0.0
 POTEVAP = POTEVAP + HREVAP
 EVAPHRS = EVAPHRS + 1
ENDIF
**********************************************************
**********************************************************
PROCEDURE RESET
**********************************************************
* Reselects the grid data set, resets the index file, and resets a number
* of variables to their initial values at the start of each pass through
* the GRID data file

SELECT GRIDAT
SET INDEX TO TOPDOWN
GO TOP
SET RELATION TO SOIL INTO C
STORE .F. TO PITCENTRE
STORE .F. TO PONDED
PONDLOSS  = 0.0
LASTSHED  = 0
NUMGRIDS  = 0
**********************************************************
**********************************************************
PROCEDURE READGRID
```

```
*************************************************************
* Reading data into memory variables from file A=GRIDAT, C=SOILDAT. This
* is done in order to avoid any unnecessary duplication of file reads. It
* is much faster to read all the data into memory variables and to do the
* computations on the memory variables than it is to repeatedly read the
* required data from disk.

NUMGRIDS   = NUMGRIDS + 1

RETAINED   = SURFH20
SD0        = SNOWDEP0
THISHED    = SHEDNO
FLOODVOL   = FLODVOL * 1000  && Temporary conversion from m to mm
MAXDEPTH   = MAXDEP
ACTINFT    = 0.0

IF DDIR = 5
 STORE .T. TO PITCENTRE
ENDIF
IF THISHED <> LASTSHED
 STORE .T. TO NEWSHED
 STORE .F. TO PITCENTRE
 LASTSHED = THISHED
 STORE .F. TO PONDED
 STORE 0.0 TO PONDLOSS
 @ 8,  17 SAY THISHED PICTURE '###'
*************************************************************
* This bit checks the pitdata file to find out the actual volume of water
* stored in the pit associated with this new shed. This actual amount is
* later compared with the volume required to flood each cell so as to
* determine if that cell is, in fact, flooded. Since pits coalesce or split
* as ponds grow or shrink it is necessary to determine which active pit is
* associated with a given watershed at a given time. This is done by
* following a pointer from any pit that is full to the pit into which it
* overflows. If this pit is not yet full then it is the current pit. If it
* is full then we continue jumping to the next pit until we encounter a
* pit that is not yet full to overflowing.
*************************************************************
 SELECT PONDAT
 GOTO THISHED
 STARTPIT  = RECNO()
 STARTPOUR = POURELEV
 TOPPOND   = STARTPIT
 MAXPOUR   = STARTPOUR
 N         = 0
 DO WHILE FULL .AND. .NOT. FINAL
  IF .NOT. VISITED
   N = N+1
   PIT[n] = RECNO()
   REPLACE VISITED WITH .T.
   GOTO DRAINSTO
  ELSE
   GOTO NEXTPIT
  ENDIF
  IF POURELEV > MAXPOUR
```

```
    MAXPOUR = POURELEV
    TOPPOND = RECNO()
   ENDIF
  ENDDO

* The following bit resets the logical variable VISITED to .F. for all
* records of pits traversed in the current search
 DO WHILE N > 0
  GOTO PIT[n]
  REPLACE VISITED WITH .F.
  N = N-1
 ENDDO

 IF MAXPOUR > STARTPOUR
  GOTO TOPPOND
 ELSE
  GOTO STARTPIT
 ENDIF

 PRESVOL  = (PREVOL + VOLINPIT) * 1000
 NEWPOND  = PRESVOL  && Note: NEWPOND = PRESVOL-PONDLOSS but
PONDLOSS = 0.0
 TOTVOL   = TOTALVOL * 1000
 SPILLSTO = SHEDNO
 DO SHEDSTAT
ENDIF

DO GRIDSTAT

SELECT GRIDAT
SET RELATION TO SOIL INTO C
*************************************************************
* This bit assigns a T/F value to the logical variable PONDED and stores
* the value of the elevation of the highest flooded grid cell to the var
* FLODELEV which represents the highest (or first) elevation at which
* a grid cell in this watershed will be flooded. All grid cells below this
* first flooded cell must also be flooded so we don't have to check any
* more cells in the current watershed once we have identified the first
* cell that floods. If a grid cell is ponded, then we know that there is
* standing water at that point. We expect evaporation at potential and
* infiltration at the maximum rate for standing water.
*************************************************************

IF .NOT. PONDED
 DO CASE
  CASE PRESVOL >= FLOODVOL  && pondloss should = 0
   STORE .T. TO PONDED
   FLODELEV = ELEV
  CASE PITCENTRE .AND. PRESVOL > 0 && empties pond for presvol<flodvol
   STORE .T. TO PONDED
   FLODELEV = ELEV
  OTHERWISE
   && DO NOTHING as either PRESVOL < FLOODVOL or PRESVOL = 0
 ENDCASE
ENDIF
```

```
****************************************************************
PROCEDURE SNOWMELT
****************************************************************
* Purpose: To compute an estimate of the likely volume of snowmelt for a
* given grid cell with a given starting snow depth (SD0) using a linear
* interpolation between previously calculated and stored reference values
* The initial snow depth (SD0) is given in mm and is read from the GRID
* file during the procedure READGRID

DO CASE
 CASE SD0 <= 50
  MELTVOL = MELT50 * (SD0/50)
 CASE SD0 < 100
  MELTVOL = MELT50 + ((MELT100 - MELT50) * ((SD0 - 50)/50))
 CASE SD0 < 150
  MELTVOL = MELT100 + ((MELT150 - MELT100) * ((SD0 - 100)/50))
 CASE SD0 < 200
  MELTVOL = MELT150 + ((MELT200 - MELT150) * ((SD0 - 150)/50))
 CASE SD0 < 300
  MELTVOL = MELT200 + ((MELT300 - MELT200) * ((SD0 - 200)/100))
 CASE SD0 < 400
  MELTVOL = MELT300 + ((MELT400 - MELT300) * ((SD0 - 300)/100))
 CASE SD0 < 500
  MELTVOL = MELT400 + ((MELT500 - MELT400) * ((SD0 - 400)/100))
 CASE SD0 < 600
  MELTVOL = MELT500 + ((MELT600 - MELT500) * ((SD0 - 500)/100))
 CASE SD0 < 700
  MELTVOL = MELT600 + ((MELT700 - MELT600) * ((SD0 - 600)/100))
 CASE SD0 < 800
  MELTVOL = MELT700 + ((MELT800 - MELT700) * ((SD0 - 700)/100))
 CASE SD0 < 900
  MELTVOL = MELT800 + ((MELT900 - MELT800) * ((SD0 - 800)/100))
 CASE SD0 < 1000
  MELTVOL = MELT900 + ((MELT1000 - MELT900) * ((SD0 - 900)/100))
 CASE SD0 < 1250
  MELTVOL = MELT1000 + ((MELT1250 - MELT1000) * ((SD0 - 1000)/250))
 CASE SD0 < 1500
  MELTVOL = MELT1250 + ((MELT1500 - MELT1250) * ((SD0 - 1250)/250))
 CASE SD0 < 1750
  MELTVOL = MELT1500 + ((MELT1750 - MELT1500) * ((SD0 - 1500)/250))
 CASE SD0 <= 2000
  MELTVOL = MELT1750 + ((MELT2000 - MELT1750) * ((SD0 - 1750)/250))
 OTHERWISE
  MELTVOL = 0.0
ENDCASE
****************************************************************
****************************************************************
PROCEDURE INFILT
****************************************************************
MS1THETA = S1THETA
MS2THETA = S2THETA
MS3THETA = S3THETA
INI1    = MS1THETA
INI2    = MS2THETA
INI3    = MS3THETA
```

```
S1ROOM  = 0.0
S2ROOM  = 0.0
S3ROOM  = 0.0
S1DELTA = 0.0
S2DELTA = 0.0
S3DELTA = 0.0
DR1     = 0.0
DR2     = 0.0
DR3     = 0.0

IF .NOT. FROZEN3
 DO S3DRAIN
ENDIF

IF .NOT. FROZEN2
 DO S2DRAIN
ENDIF

DO S1DRAIN

* If there has been any change in the water content of any of the stores
* (S1, S2, S3) then it is necessary here to store the new, updated water
* content into the main database for that grid cell location

IF MS3THETA <> INI3
 REPLACE S3THETA WITH MS3THETA
ENDIF
IF MS2THETA <> INI2
 REPLACE S2THETA WITH MS2THETA
ENDIF
IF MS1THETA <> INI1
 REPLACE S1THETA WITH MS1THETA
ENDIF
DO PONDSTAT

* The final result of all of this is to return an updated value for
* surface water volume (SURFVOL) after any infiltration has taken place.
* A related side effect is to update the estimate of current water content
* in each of the 3 soil stores (S1THETA, S2THETA, S3THETA) if that water
* content has been changed by infiltration and drainage.
***********************************************************

***********************************************************
PROCEDURE S3DRAIN
***********************************************************
MK3SAT  = C->FC3
MS3SAT  = C->VOLTP3
MS3MIN  = C->VOLFP3
MGWC3   = C->GWC3
S3ROOM  = MS3SAT - MS3THETA  && Equivalent to PIV in ANSWERS

DO CASE
 CASE MS3THETA <= MS3MIN
  DR3 = 0.0
  MS3THETA = MS3MIN
```

```
 CASE S3ROOM = 0
  DR3 = MK3SAT
 CASE MGWC3 = 0
  DR3 = 0.0
 OTHERWISE
  DR3 = MK3SAT * (1 - S3ROOM/MGWC3)**3
ENDCASE

* Start of determination of downward seepage from S3 into undefined subsurf
* NOTE: May need to define some very slow DR4 same everywhere that limits
* rate of outflow from final saturated store S3 into depressions or bedrock
IF DR3 > 0.0
 S3DELTA = DR3 * DeltaT
*  IF DR3 <= DR4
*   S3DELTA = DR3 * DeltaT
*  ELSE
*   S3DELTA = DR4 * DeltaT
*  ENDIF && Commented out so that S3DELTA always = DR3*DeltaT

 MS3NEW = MS3THETA - S3DELTA
 IF MS3NEW > MS3MIN
  MS3THETA = MS3NEW
 ELSE
  MS3THETA = MS3MIN
  S3DELTA  = MS3THETA - MS3MIN
 ENDIF
 S3ROOM   = MS3SAT - MS3THETA
*  SATSTORE = SATSTORE + S3DELTA && May use this later to track sat flow
ENDIF

* Downward seepage only occurs if the drainage rate from S3 (DR3) INTO S4
* (DR4) is greater than 0 and produces S3DELTA > 0

DO S3STAT
***********************************************************
***********************************************************
PROCEDURE S2DRAIN
***********************************************************
* Reads Store2 soil data and computes drainage from Store2 if not frozen
MK2SAT   = C->FC2
MS2SAT   = C->VOLTP2
MS2MIN   = C->VOLFP2
MGWC2    = C->GWC2
S2ROOM   = MS2SAT - MS2THETA  && Equivalent to PIV in ANSWERS
DO CASE
 CASE MS2THETA <= MS2MIN
  DR2 = 0.0
  MS2THETA = MS2MIN
 CASE S2ROOM = 0
  DR2 = MK2SAT
 CASE MGWC2 = 0
  DR2 = 0.0
 OTHERWISE
  DR2 = MK2SAT * (1 - S2ROOM/MGWC2)**3
ENDCASE
```

```
 * Start of determination of downward seepage from S2 into S3

 IF S3ROOM > 0.0
  S2DELTA = DR2 * DeltaT
 *  DO CASE
 *    CASE DR2 <=DR3
 *      S2DELTA = DR2 * DeltaT
 *    CASE MS3THETA > MS3MIN
 *      S2DELTA = DR3 * DeltaT
 *    OTHERWISE
 *      S2DELTA = DR2 * DeltaT
 *  ENDCASE && Commented out so that S2DELTA always = DR2*DeltaT

 * Above selects the lower drainage rate DR2 or DR3 to estimate the maximum
 * possible rate of downward seepage from S2 to S3 (S2DELTA) except when
 * the soil moisture in S3 is < field capacity when drainage occurs at the
 * rate governed by the overlying horizon.

  IF S2DELTA > 0
   IF MS2THETA - S2DELTA < MS2MIN
    S2DELTA  = MS2THETA - MS2MIN
   ENDIF
 * Above reduces downward seepage flux S2DELTA if it would have lowered
 * the water content of store S2 below the estimated field capacity S2MIN

 * Below if the amount of room available in store S3 exceeds the estimated
 * maximum downward flux S2DELTA then S2DELTA is removed from S2 and added
 * to S3 water content.
   IF S2DELTA < S3ROOM
    MS3THETA = MS3THETA + S2DELTA
    MS2THETA = MS2THETA - S2DELTA
   ELSE
 * ie if there is less room in store 3 than needed for the expected seepage
 * then only as much water is passed as can fit into store S3
    S2DELTA  = S3ROOM
    MS3THETA = MS3SAT
    MS2THETA = MS2THETA - S2DELTA
   ENDIF
   S2ROOM = MS2SAT - MS2THETA
  ENDIF
ENDIF
DO S2STAT  && Updates screen with latest values for Store2 moisture data
************************************************************
************************************************************
PROCEDURE S1DRAIN
************************************************************
* Reads Store1 soil data and computes drainage from Store2 if not frozen

DO READS1  && Reads in the data required to compute infiltration for cell

S1ROOM  = MS1SAT - MS1THETA  && Equivalent to PIV in ANSWERS

DO CASE
 CASE MS1THETA <= MS1WP
```

```
   DR1 = 0.0
   MS1THETA = MS1WP
  CASE MS1THETA <= MS1MIN
   DR1 = 0.0
  CASE S1ROOM = 0
   DR1 = MK1SAT
  CASE MGWC1 = 0
   DR1 = 0.0
  OTHERWISE
   DR1 = MK1SAT * (1 - S1ROOM/MGWC1)**3
ENDCASE

* NOTE: If S1ROOM = 0 (ie no room = saturated)  DR1 = MK1SAT (ie FC1)
*       If MS1THETA < MS1MIN (below field cap)  DR1 = 0 (ie no drainage)
*       If MGCW1 = 0 (no gravitational water)   DR1 = 0 (ie no drainage)

* Start of determination of downward seepage from S1 into S2

IF S2ROOM > 0.0
 S1DELTA = DR1 * DeltaT
* DO CASE
*   CASE DR1 <= DR2
*    S1DELTA = DR1 * DeltaT    && mm/hr * hrs
*   CASE MS2THETA <= MS2MIN
*    S1DELTA = DR1 * DeltaT
*   OTHERWISE
*    S1DELTA = DR2 * DeltaT
* ENDCASE && Commented out so that S1DELTA always = DR1 * DeltaT
* Above selects the lower drainage rate DR1 or DR2 to estimate the maximum
* possible rate of downward seepage from S2 to S3 (S2DELTA)
 IF S1DELTA > 0
  IF MS1THETA - S1DELTA < MS1MIN
   S1DELTA  = MS1THETA - MS1MIN
  ENDIF
* Above reduces downward seepage flux S1DELTA if it would have lowered
* the water content of store S1 below the estimated field capacity S1MIN

* Below if the amount of room available in store S2 exceeds the estimated
* maximum downward flux S1DELTA then S1DELTA is removed from S1 and added
* to S2 water content.
  IF S1DELTA < S2ROOM
   MS2THETA = MS2THETA + S1DELTA
   MS1THETA = MS1THETA - S1DELTA
  ELSE
* ie if there is less room in store 2 than needed for the expected seepage
* then only as much water is passed as can fit into store S2
   S1DELTA  = S2ROOM
   MS2THETA = MS2SAT
   MS1THETA = MS1THETA - S1DELTA
  ENDIF
 ENDIF
ENDIF
DO S1INFT  && Only worthwhile infiltration if H20 or ponded on surface
*****************************************************************
```

```
*************************************************************
PROCEDURE S1INFT
*************************************************************
* Now we have arrived at point where we have allowed water to seep down
* from S3->S4 then S2->S3 then S1->S2. So we know the new estimated water
* content (MS1THETA) of S1 after one time step worth of infiltration.
* We now have to allow whatever excess water there is at the surface from
* RAIN + SNOWMELT + RETAIN a chance to infiltrate. It should infiltrate at
* a rate FMAX. If SURFVOL < INFLUX1 then all SURFVOL water on the surface
* will be able to infiltrate. If SURFVOL > FMAX * DeltaT = INFLUX1 then
* not all of the SURFVOL surface water can inflitrate (only INFLUX1) and
* the rest (SURFVOL = SURFVOL - INFLUX1) must run off

* The following infiltration computations are patterned after concepts and
* equations presented in the ANSWERS model (Beasley and Huggins, 1981).
* A maximum rate of infiltration is estimated by FMAX=FC+A*((PIV/TP)**P)

S1ROOM  = MS1SAT - MS1THETA  &&  S1 recomputed here due to changes above

DO CASE
 CASE MS1SAT <= 0.0
  FMAX = 0.0
 CASE S1ROOM = 0.0
  FMAX = MK1SAT
 CASE S1ROOM = MS1SAT
  FMAX = MK1SAT + MA**MP
 OTHERWISE
  FMAX   = MK1SAT + MA * (S1ROOM/MS1SAT)**MP
ENDCASE

INFLUX1 = FMAX * DeltaT

* Infiltration is conceptualised as occurring under two possible
* conditions. The first occurs when water ponded in micro-depressions
* (FWA) infiltrates into the soil. The other occurs when rainfall or
* snowmelt fall directly on raised micro-ridges and either infiltrate
* directly into the soil on these ridges or, partially infiltrate and
* partially run off into the micro-depressions. Runoff occurs if the
* rate of precipitation exceeds the rate of infiltration or the available
* storage capacity of the surface soil.

* The idea as adopted from ANSWERS is that the non-ponded area is computed
*  first and any rainfall+snowmelt can infiltrate into it. Then the ponded
* area is considered and any remaining portion of rain and snow, plus any
* water stored in micro-depressions can infiltrate at the rate FMAX which
* is adjusted according to the proportion of flooded area.

IF INFLUX1 > S1ROOM
 INFLUX1 = S1ROOM
ENDIF
* The above reduces the estimated infiltration flux (INFLUX1) to the
* amount of pore space remaining unfilled in the infiltration zone if
* the remaining space is smaller than the maximum potential flux

PPT    = RAIN + MELTVOL
```

```
* The computation for estimating infiltration starts here!

IF .NOT. PONDED

 DO SOILINFT

ELSE   && ie if the grid cell in question is flooded by macro-ponding

 FILLDIFF = MAXDEPTH - RETAINED && Check to see if retention is full to max
 DO CASE  && If retention not full to max fill retention from pond H20
  CASE FILLDIFF <= 0.0  && ie RETAINED >= MAXDEPTH
   && DO NOTHING as retention is full to maxdepth or more

  CASE NEWPOND >= FILLDIFF && Pond H20 more that enough to fill retention
   PONDLOSS = PONDLOSS + FILLDIFF
   RETAINED = MAXDEPTH
   SURFVOL  = MAXDEPTH + PPT
   REPLACE SURFH20 WITH MAXDEPTH
   NEWPOND = PRESVOL - PONDLOSS  && Recompute NEWPOND as per new
PONDLOSS

  CASE NEWPOND <= 0.0
   && DO NOTHING as there is no pondwater to use to fill retention

  CASE NEWPOND < FILLDIFF  && Not enough pond H20 to fill retention to max
   PONDLOSS = PRESVOL    && ie PONDLOSS + PRESVOL - PONDLOSS
   RETAINED = RETAINED + NEWPOND
   SURFVOL  = RETAINED + PPT
   NEWPOND  = 0.0
   REPLACE SURFH20 WITH RETAINED
 ENDCASE

 DO CASE

  CASE INFLUX1 <= 0.0
   ACTINFT = 0.0
*  Do nothing as there has been no change due to infiltration

  CASE NEWPOND - INFLUX1 >= FLOODVOL
*  In this case there is sufficient water in the pond to cover all
*  potential infiltration (INFLUX1) so all infiltration is used to
*  reduce the volume of water stored in the pond.
   PONDLOSS = PONDLOSS+INFLUX1   && All infilt comes from pondloss
   MS1THETA = MS1THETA + INFLUX1 && Increase moisture in S1 by INFLUX1
   ACTINFT  = INFLUX1

  CASE NEWPOND > FLOODVOL
*  In this case there is sufficient water in the pond even after all
*  infiltration losses within the pond area in this time step for the
*  grid cell to remain flooded, but not sufficient water to cover all
*  of the estimated loss by infiltration through this grid cell in this
*  time step. All remaining water in the pond infiltrates first then
*  any water remaining in surface retention is allowed to infiltrate up
*  to the maximum of the computed flux (S1THETA) or the total amount of
```

```
*  water in surface retention (whichever is less)
    ACTINFT  = NEWPOND - FLOODVOL
    PONDLOSS = PONDLOSS + ACTINFT
    MS1THETA = MS1THETA + ACTINFT
    INFLUX1  = INFLUX1 - ACTINFT
    DO SOILINFT

   OTHERWISE
*  In this case, the present pond volume is below that required to flood
*  this grid cell, due to reductions caused by infiltration in ponded
*  cells higher in elevation and previously processed.
    DO SOILINFT
 ENDCASE
ENDIF
DO S1STAT
**********************************************************
**********************************************************
PROCEDURE SOILINFT
**********************************************************
* This procedure computes the infiltration of water into the soil. It
* spilts infiltration into 2 stages. In the first, water from rainfall
* and snowmelt (if any) infiltrates into the area of ridges not affected
* by micro-ponding. This will be true in all cases except when the amount
* of water stored in surface retention is equal to the maximum possible
* surface retention (ie the furrows are full to the top). In the second
* stage, infiltration occurs from the flooded micro-depressions associated
* with surface retention into whatever space remains in the surface layer
* to accept infiltration. This continues until all remaining water in
* surface retention has infiltrated or the allowable flux of water into
* the surface has been achieved.
**********************************************************

* NOTE: RETAINED = SURFH20 and is read during READGRID for each cell
* NOTE: SURFVOL = RETAINED + RAIN + MELTVOL as computed in main program
IF SURFVOL > 0.0 .AND. INFLUX1 > 0.0
 IF RETAINED < MAXDEPTH
*   ROUGH   = C->RC
*   HU      = C->HU1
   IF ROUGH > 0 .AND. HU > 0
    FH     = RETAINED/HU/ROUGH  &&  RETAINED == DEP IN ANSWERS!
    FWA    = FH**(1-ROUGH)
   ELSE
    FWA = 1
   ENDIF
   IF PPT > 0.0
    TROFPPT  = PPT * FWA
    RIDGEPPT = PPT - TROFPPT
    IF RIDGEPPT < INFLUX1
        MS1THETA = MS1THETA + RIDGEPPT
        ACTINFT  = ACTINFT + RIDGEPPT
        INFLUX1  = INFLUX1 - RIDGEPPT
        PPT      = TROFPPT
    ELSE     && ie RIDGEPPT > INFLUX1
        MS1THETA = MS1THETA + INFLUX1
        ACTINFT  = ACTINFT + INFLUX1
```

```
        INFLUX1  = 0.0
        TROFPPT  = TROFPPT + (RIDGEPPT - INFLUX1)
        PPT      = TROFPPT
    ENDIF
    SURFVOL = RETAINED + TROFPPT
  ENDIF
 ENDIF
* This bit is done after infiltration on ridges and applies in all cases
* where there is any surface water to infiltrate and any room in store S1
* to accommodate infiltration.
 IF SURFVOL < INFLUX1
  MS1THETA = MS1THETA + SURFVOL
  ACTINFT  = ACTINFT + SURFVOL
  SURFVOL  = 0.0
 ELSE
  MS1THETA = MS1THETA + INFLUX1
  ACTINFT  = ACTINFT + INFLUX1
  SURFVOL  = SURFVOL - INFLUX1
 ENDIF
ENDIF
************************************************************
************************************************************
PROCEDURE EVAP
************************************************************

* Finally, it is necessary to reduce the moisture at or in the surface
* by an amount equal to the actual maximum possible evaporation
* This depends upon whether the surface is ponded, fully saturated, or
* partially saturated

* DON"T FORGET to increase PONDLOSS if evaporation at this cell removes
* water from the pond rather than the excess surface water or the soil

THISEVAP = POTEVAP  && New mem variable to insure POTEVAP doesn't change

IF .NOT. PONDED
 DO SOILEVAP
ELSE  && ie if the grid cell is ponded (less likely condition)
 NEWPOND = PRESVOL - PONDLOSS
 DO CASE

   CASE NEWPOND - THISEVAP >= FLOODVOL
*  The pond contains enough water to keep this grid cell flooded even
*  after the volume of evaporation up to and including this time step
*  is removed from the last known volume of this pond.
    EVAPVOL   = THISEVAP
    PONDLOSS  = PONDLOSS + THISEVAP
    THISEVAP  = 0.0
   CASE NEWPOND > FLOODVOL
*  The volume of water currently in the pond exceeds the volume required
*  to flood this grid cell, but is not sufficiently large to meet all of
*  the evaporative demand for this cell in this time step. The pond
*  volume can only be reduced to the level at which it no longer floods
*  this grid cell. Any potential evaporation remaining must remove water
*  from surface retention first then from the soil
```

```
    EVAPVOL  = NEWPOND - FLOODVOL  && Vol H20 pond can lose by evap
    THISEVAP = THISEVAP - EVAPVOL  && Current POTEVAP reduced by amt
    PONDLOSS = PONDLOSS + EVAPVOL  && of H20 removed from pond above
    DO SOILEVAP

   OTHERWISE  && ie NEWPOND < FLOODVOL
*  Even before this evaporation the pond volume has fallen below the
*  level required to flood this cell so no evaporation can come from
*  the pond volume. All must come from retention first then from the soil
    DO SOILEVAP
 ENDCASE
ENDIF
DO PONDSTAT
**************************************************************
**************************************************************
PROCEDURE SOILEVAP
**************************************************************
* This code is extracted as a separate procedure since it is reused at
* several different locations in the EVAP procedure. It removes water
* from surface retention up to the limit of the potential evaporation
* If there is not sufficient water in surface retention to satisfy the
* total evaporative demand, then that portion of the demand remaining
* after all water has been removed from retention is applied to removing
* moisture from the soil. If the rate of movement of water through the
* soil limits the moisture that can be supplied to less than the remaining
* potential evaporation then only as much evaporation takes place as can
* be satisfied by the rate at which water moves out of the soil.
**************************************************************

IF SURFVOL < THISEVAP && Not enough H20 on surface to satisfy evap demand
 IF .NOT. FROZEN1   && therefore compute rate at which soil can supply
  S1ROOM   = MS1SAT - MS1THETA        && Equivalent to PIV in ANSWERS
  DO CASE
   CASE S1ROOM = 0
       ERATE1 = MK1SAT
   CASE MS1THETA <= MS1WP
       ERATE1 = 0.0
   CASE S1ROOM < 0
       ERATE1 = 0.0
   OTHERWISE
       MAXDIFF1 = MS1SAT - MS1WP
       ERATE1 = MK1SAT * (1 - S1ROOM/MAXDIFF1)**3
           && Note change from ANSWERS formula uses wilting point
  ENDCASE
 ELSE
  DO READS1
  ERATE1 = 0.0          && If soil frozen drain rate set to zero
 ENDIF
 UPLOSS  = ERATE1 * EVAPHRS  && Use # Hrs with potevap > 0 rather than
*                            && using total number of hours in this step
 MAXLOSS = MS1THETA - MS1WP  && can't allow soil water to fall below WP
 IF UPLOSS > MAXLOSS
  UPLOSS = MAXLOSS
 ENDIF
```

```
  EVAPVOL   = SURFVOL
  THISEVAP  = THISEVAP - SURFVOL
  SURFVOL   = 0.0
  IF THISEVAP < UPLOSS            && All remaining Pot Evap satisfied by soil
   EVAPVOL  = THISEVAP
   UPLOSS   = THISEVAP
  ELSE                            && Movement from soil limits evaporation
   EVAPVOL  = EVAPVOL + UPLOSS
  ENDIF
  IF UPLOSS > 0.0
   MS1THETA = MS1THETA - UPLOSS
   DO CASE                        && Probably don't need this.
    CASE MS1THETA < MS1WP         && Put in to trap unexplained errors
       MS1THETA = MS1WP           && That pushed S1THETA above S1SAT and
    CASE MS1THETA > MS1SAT        && below S1WP
       MS1THETA = MS1SAT
    OTHERWISE
       && DO NOTHING AS NEW VALUE IS ALLOWABLE
   ENDCASE
   REPLACE S1THETA WITH MS1THETA
  ENDIF
ELSE
* ie available surface water(SURFVOL) > potential evaporation(POTEVAP)
 SURFVOL   = SURFVOL - THISEVAP
 EVAPVOL   = THISEVAP
ENDIF
*************************************************************
*************************************************************
PROCEDURE FLOWDOWN
*************************************************************
CURRENT = RECNO()
NEXTCELL = DREC
GOTO NEXTCELL
REPLACE SURFH20 WITH SURFH20 + RUNOFF
GOTO CURRENT
*************************************************************
*************************************************************
PROCEDURE PONDVOL
*************************************************************
* This procedure determines whether there is any net change to the volume
* of water stored in the current pit after one complete pass through the
* GRID cells comprising a given watershed area. If there is a positive
* change we need to ADD a certain volume of water to the pond that is
* presently fed by this watershed. This is relatively simple. We simply
* follow the path through the PITDATA file and arrive at the first pit
* that is not yet full (or flooded). We add the new amount equivalent to
* PONDDIFF to this new pit. If the addition results in the volume of water
* assigned to that pit exceeding the total volume for which there is room
* in the pit (VOLTOFLOOD) then we simply fill up the current pit to its
* maximum total capacity then move up to the next pit and add any volume
* of runoff remaining to the next pond up in the sequence.
*
* The problem is more complicated if PONDIFF is negative and we have to
* remove water from a pond to simulate a PONDLOSS or PITLOSS. In this
* case it is necessary to first determine which of any possible parent
```

```
* pits floods or contains the initial pit. The parent pit that occurs
* at the highest level in the pit hierarchy and ALSO subsumes or
* floods the initial pit catchment is the pit from which we must remove
* the excess water. If removal of water from this pit brings its volume
* below 0 or below the minimum volume required to flood the initial pit
* then we must lower the volume only to this base level, then move back
* to the next lowest pit that also floods the initial pit. If you think
* it is hard to understand this explaination you should have tried to be
* in on the process of figuring out how to code this algorithm!!!

IF PONDLOSS < 0.0
 PONDLOSS = 0.0
ENDIF
IF SURFVOL < 0.0
 SURFVOL = 0.0
ENDIF

* ie. SURFVOL for the pit centre contains the sum of all runoff added to
* the pit in this time step while pondloss contains the sum of all losses
* from the pond in this time step due to infiltration or evaporation

* ie PONDLOSS is any loss minus any gain from runoff in this timestep
* NOTE: Division by 1000 is used to convert from the units of mm used in
*     computations of infiltration, evaporation and runoff to the units
*     of metres (m) used to describe the volume of water in the ponds.


DO CASE
 CASE SURFVOL = PONDLOSS
  PONDIFF  = 0.0
  PONDLOSS = 0.0

 CASE SURFVOL < PONDLOSS
  PONDIFF  = (SURFVOL - PONDLOSS) / 1000
  PONDLOSS = (PONDLOSS - SURFVOL) / 1000
  SELECT PONDAT
  GOTO THISHED
  DO PONDLOWER

 CASE SURFVOL > PONDLOSS
  PONDIFF  = (SURFVOL - PONDLOSS) / 1000
  PONDLOSS = 0.0
  SELECT PONDAT
  GOTO THISHED
  DO PONDADD

 OTHERWISE
*   DO NOTHING
ENDCASE
SELECT GRIDAT
SET RELATION TO SOIL INTO C
**************************************************************
```

```
***********************************************************
PROCEDURE PONDADD
***********************************************************
* This procedure is called when there is a net positive change in the
* volume of water arriving at the pit centre of a given watershed pit
* at the end of a single sweep through the grid cells of that watershed
* for a single time step. This means that we want to add water to the
* pond being fed at the present time by the cells of the watershed just
* processed. If the pond centered on the pit centre is full it may either
* be overspilling, in which case excess water will have to be passed to
* the grid cell in the main data matrix where overspill takes place, or it
* may be that the initial pond has been subsumed by a higher level pond
* that covers and includes the initial pond. In this case it is necessary
* to add water to the subsuming pond until it reaches its overspill volume
* and then to check to see if it overspills or is subsumed in its turn.
* The operation is completed when all excess water has either been added
* to storage in a higher level pond or passed to an overspill cell to
* continue on its journey to the next lowest connected pit.

* DECLARE PIT[50]    && sets up an array for tracking path through pits
N       = 0

DO WHILE PONDIFF > 0.0
 STARTPIT  = RECNO()    && Keeps track of initial pit number
 TOP_PIT   = STARTPIT   && keeps track of the pit with highest pour elev
 STARTPOUR = POURELEV   && keeps track of the initial pour elevation
 MAXPOUR   = STARTPOUR  && keeps track of the maximum pour elevation
 POUR2     = .F.        && Becomes true if switch is made to NEXTPIT
 REPLACE VISITED WITH .F.
 DO WHILE FULL .AND. .NOT. FINAL
  IF .NOT. VISITED
   N      = N+1
   PIT[n] = RECNO()
   REPLACE VISITED WITH .T.
   GOTO DRAINSTO
  ELSE  && If this pit has previously been visited or checked
   IF POURELEV = MAXPOUR
      STORE .T. TO POUR2
   ENDIF
   GOTO NEXTPIT
  ENDIF

  IF POURELEV > MAXPOUR
   MAXPOUR = POURELEV
   TOP_PIT = RECNO()
   POUR2   = .F.                && Precautionary resetting of logical var POUR2
  ENDIF
 ENDDO

 IF MAXPOUR > STARTPOUR
  GOTO TOP_PIT
  POURPOINT = POUREC
 ELSE
  GOTO STARTPIT
  IF POUR2
```

```
    POURPOINT = POUREC2
   ELSE
    POURPOINT = POUREC
   ENDIF
  ENDIF

  DO CASE
   CASE FINAL

    DO CASE
       CASE FULL
* All of pondiff is involved in flow away from pit-record this in FLOWFILE
        SELECT FLOWDAT
        APPEND BLANK
        REPLACE PITNO WITH THISHED
        REPLACE DAY WITH TODAY
        REPLACE HOUR WITH THISHOUR
        REPLACE FLOWVOL WITH PONDIFF
        PONDIFF = 0.0
        SELECT PONDAT

       CASE VOLINPIT + PONDIFF < VOLTOFLOOD
        REPLACE VOLINPIT WITH VOLINPIT + PONDIFF
        PONDIFF = 0.0

       CASE VOLINPIT + PONDIFF >= VOLTOFLOOD
        PONDIFF = PONDIFF - (VOLTOFLOOD - VOLINPIT)
        REPLACE VOLINPIT WITH VOLTOFLOOD
        REPLACE FULL WITH .T.
    ENDCASE


   CASE FULL
    OVERFLOW  = PONDIFF * 1000
    SELECT GRIDAT
    CURRENT = RECNO()
    GOTO POURPOINT
    REPLACE SURFH20 WITH SURFH20 + OVERFLOW
    GOTO CURRENT
    PONDIFF = 0.0

   CASE VOLINPIT + PONDIFF < VOLTOFLOOD
    REPLACE VOLINPIT WITH VOLINPIT + PONDIFF
    PONDIFF = 0.0

   CASE VOLINPIT + PONDIFF >= VOLTOFLOOD
    PONDIFF = PONDIFF - (VOLTOFLOOD - VOLINPIT)
    REPLACE VOLINPIT WITH VOLTOFLOOD
    REPLACE FULL WITH .T.

  ENDCASE
ENDDO

* The following bit resets the logical variable VISITED to .F. for all
* records of pits traversed in the current search
```

```
SELECT PONDAT   && DO I NEED THIS???? HERE

DO WHILE N > 0
 GOTO PIT[n]
 REPLACE VISITED WITH .F.
 N = N-1
ENDDO
**************************************************************
**************************************************************
PROCEDURE PONDLOWER
**************************************************************
* This procedure is used to remove water from storage in ponds (recorded
* in the field VOLINPIT in PONDATA.dbf). It is necessary to first assess
* whether the initial starting pond has been flooded by and therefore
* subsumed by any other higher order ponds. We trace through the pointers
* connecting all ponds that are currently FULL (and therefore overspilled)
* until we reach the first pond that is NOT FULL. As we go we note and
* record the record numbers of any connected ponds which have a higher
* overspill elevation than the current highest pour point. Such ponds must
* by definition contain and subsume all ponds with lower pour elevations
* We make a sequential list of only those ponds with higher pour elevations
* We then remove water from the highest subsuming pit till it is empty
* then go to the next highest and remove any remaining PONDLOSS and so
* on until all the computed PONDLOSS has been accounted for.

* One additional requirement was to define a construct which I called
* FINAL which identified any pits which drained to the outside world as
* FINAL pits (ie FINAL = .T.) If a pit is a FINAL pit then there is no
* point in trying to compute its water balance as we lack information on
* the influence of the landscape outside the DEM data set on flow into or
* away from these points so it is not possible to compute ponding.

* DECLARE PIT[50]    && sets up an array for tracking path through pits
* DECLARE POND[15]
P      = 1
N      = 1
PIT[N]  = RECNO()   && RECNO() is equivalent to SHEDNO in PONDATA.dbf
POND[P] = RECNO()   && Record no. of Starting or lowest elevation pond
MAXPOUR = POURELEV  && PourElev is read from the PONDATA.dbf
REPLACE VISITED WITH .F.

* The following bit walks up through the pond linkage pointers from the
* starting pit through all connected pits that are FULL. It checks to see
* if the overspill elevation of any of the ponds that are currently fed
* by the starting pit watershed is higher that the highest overspill elev
* to date. The highest overspill elevation to date is always updated. Any
* subsequent pits that have a higher overspill elevation must flood all
* pits traversed so far.

DO WHILE FULL .AND. .NOT. FINAL
 IF .NOT. VISITED
  PIT[n] = RECNO()
  REPLACE VISITED WITH .T.
  GOTO DRAINSTO
```

```
    N = N+1
  ELSE  && If this pit has previously been visited or checked
    GOTO NEXTPIT
  ENDIF

  IF POURELEV > MAXPOUR
    MAXPOUR = POURELEV
    P = P+1
    POND[P] = RECNO()
  ENDIF
ENDDO

* The record number POND[P] identifies the highest level pond which floods
* or subsumes the initial pit at which we started our search. Any water to
* be removed must be completely removed from the higher level pond before
* proceeding to remove water from lower level ponds.
GOTO POND[P]

DO WHILE PONDLOSS > 0.0
  DO CASE
    CASE FINAL
      IF VOLINPIT > PONDLOSS   && (ie All loss is from this pit)
          REPLACE VOLINPIT WITH VOLINPIT - PONDLOSS
          PONDLOSS = 0.0
      ELSE   && (ie Volinpit < Pondloss - not enough in pit to cover loss)
          PONDLOSS = PONDLOSS - VOLINPIT
          REPLACE VOLINPIT WITH 0.0
          REPLACE FULL WITH .F.
          IF P > 1
            P = P-1
            GOTO POND[P]
          ELSE
            PONDLOSS = 0.0
          ENDIF
      ENDIF
      REPLACE FULL WITH .F.

    CASE VOLINPIT >= PONDLOSS  && (ie All loss can be taken from this pit)
      REPLACE VOLINPIT WITH VOLINPIT - PONDLOSS
      PONDLOSS = 0.0
      REPLACE FULL WITH .F.

    CASE VOLINPIT <= PONDLOSS
      PONDLOSS = PONDLOSS - VOLINPIT
      REPLACE FULL WITH .F.
      REPLACE VOLINPIT WITH 0.0
      P = P - 1
      IF P > 0
          GOTO POND[P]
      ELSE
          PONDLOSS = 0.0
* This is used to get rid of any pond loss that may be left if the
* computed potential loss from evaporation and infiltration exceeds the
* amount of water actually left in the bottom level pit.
      ENDIF
```

```
 ENDCASE
ENDDO

* The following bit resets the logical variable VISITED to .F. for all
* records of pits traversed in the current search

IF N > 1
 N = N - 1
ENDIF
DO WHILE N > 0
 GOTO PIT[n]
 REPLACE VISITED WITH .F.
 N = N-1
ENDDO
************************************************************
************************************************************
PROCEDURE OUTPUT
************************************************************
* This procedure is used to produce one or more types of output for the
* specific days and hours for which output has been requested. A variable
* called OUTCHOICE is assigned a value based on the value stored in the
* field OUT in the METFILE data base table. If the value of OUTCHOICE is
* greater than zero (0) then some form of output is required. The choices
* available are:  1) a list of pond depth for each grid cell in a format
*                    suitable for use to produce maps in IDRISI
*                 2) a dBase III+ data base file of PONDATA information
*                 3) a dBase III+ data base file listing the current
*                    estimated soil moisture content and/or depth of
*                    ponding for each grid cell in the data set
*                 4) any combination of the above
************************************************************

OUTMAP  = OUTPATH+"POND"+LTRIM(STR(TODAY))+".TXT"
OUTPOND = OUTPATH+"PONDS"+LTRIM(STR(TODAY))
OUTSOIL = OUTPATH+"SOILS"+LTRIM(STR(TODAY))

DO CASE
 CASE OUTCHOICE = 1
  DO DEPMAP
 CASE OUTCHOICE = 2
  DO PONDDBF
 CASE OUTCHOICE = 3
  DO SOILDBF
 CASE OUTCHOICE = 4
  DO DEPMAP
  DO PONDDBF
 CASE OUTCHOICE = 5
  DO DEPMAP
  DO PONDDBF
  DO SOILDBF
 OTHERWISE
ENDCASE
************************************************************
```

```
****************************************************************
PROCEDURE DEPMAP
****************************************************************
* This sub-procedure is used to produce a simple ASCII file list of the
* depth of ponding for each grid cell. The list is sequential by row by
* column from top left to bottom right. As such it is suitable for
* immediate entry into IDRISI for production of raster maps. It is a
* simple matter to reformat this output data to produce a matrix of m
* rows by n columns for use in PC-GEOSTAT or other raster packages to
* display, overlay or compare maps. It is faster to reformat the data
* outside this system than to produce it in matrix format here.
****************************************************************

SELECT GRIDAT
SET INDEX TO
GO TOP
COPY TO &OUTMAP FIELDS PONDEP DELIMITED WITH BLANK WHILE
NOABORT()
****************************************************************
****************************************************************
PROCEDURE PONDDBF
****************************************************************
* This sub-procedure is used to write out a dBase III+ data base table
* containing information about the current status of the various ponds
* at the selected time. The main item of interest is the current total
* volume of water estimated to be stored in a pond at a given time.
* Because some ponds may be over-flooded by larger subsuming ponds we
* also include information on whether a particular pond is full and if
* so to which upper pond it is currently connected and delivering its
* excess water.
****************************************************************
SELECT PONDAT
GO TOP
COPY TO &OUTPOND FIELDS SHEDNO, VOLINPIT, PREVOL, TOTALVOL,
FULL;
WHILE NOABORT()
****************************************************************
****************************************************************
PROCEDURE SOILDBF
****************************************************************
* This sub-procedure is used to write out a dBase III+ data base table
* containing information about the currently estimated status of soil
* moisture at every grid location in the data set and the depth of ponding
* at those grid cells where ponding is estimated to occur at this time.
****************************************************************
SELECT GRIDAT
SET INDEX TO
GO TOP
COPY TO &OUTSOIL FIELDS
ROW,COL,SURFH20,S1THETA,S2THETA,S3THETA,PONDEP;
WHILE NOABORT()
****************************************************************
```

```
****************************************************************
PROCEDURE ZEROARRAY
****************************************************************
* This sub-procedure is used to set all values in the arrays PIT[N] and
* POND[N] to zero and then to reset the value of N to 0.
****************************************************************

FOR N = 1 TO 50
 STORE 0 TO PIT[N]
NEXT

FOR N = 1 TO 15
 STORE 0 TO POND[N]
NEXT
N = 0
****************************************************************
****************************************************************
FUNCTION NOABORT
****************************************************************
RETURN( INKEY() <> 27 )
****************************************************************
****************************************************************
PROCEDURE CHEKZERO
****************************************************************
* Procedure checks to see if either of the variables SURFVOL or PONDLOSS
* have been assigned a negative value. They should never have a negative
* value so if they become negative it is necessary to stop the program
****************************************************************
IF SURFVOL < 0.0 .OR. PONDLOSS < 0.0
 DO CASE
   CASE SURFVOL < 0.0 .AND. PONDLOSS < 0.0
    STORE "Both" TO PROBLEM
   CASE SURFVOL < 0.0
    STORE "SURFVOL" TO PROBLEM
   CASE PONDLOSS < 0.0
    STORE "PONDLOSS" TO PROBLEM
   OTHERWISE
 ENDCASE
 @ 24, 0 SAY "Program detects FATAL ERROR! Negative value for: "+;
            LTRIM(PROBLEM)
 INKEY() = 27
ENDIF
****************************************************************
****************************************************************
PROCEDURE METSTAT
****************************************************************
* Displays current met data to the screen
@ 13, 17 SAY DeltaT  PICTURE "##"
@ 16, 17 SAY TODAY   PICTURE '###'
@ 18, 17 SAY RAIN    PICTURE "###.##"
@ 19, 17 SAY POTEVAP PICTURE "###.##"
****************************************************************
```

```
*************************************************************
PROCEDURE SHEDSTAT
*************************************************************
* This procedure updates the status screen at the start of processing for
* each new watershed in the grid data file.
* In practice there is one update for each completed pass through each
* watershed in the main GRID data file

GRIDPCT  = NUMGRIDS/MAXGRIDS
METPCT   = (METREC/TOTALMET )

@ 18, 67 SAY (GRIDPCT*100) PICTURE "###.#"
@ 19, 67 SAY (METPCT*100)  PICTURE "###.#"
@ 8,  17 SAY THISHED  PICTURE '###'
@16, 39 SAY TOTVOL   PICTURE "########"  && = TOTALVOL OF PIT
@17, 39 SAY PRESVOL  PICTURE "########"  && =
VOLINPIT+PREVOL-PONDLOSS
@18, 39 SAY PONDLOSS PICTURE "######.#" && EVAP FROM POND THIS
STEP
@19, 39 SAY SPILLSTO PICTURE "###"   && NUMBER OF CURRENT TOP
POND
DOTSTRING = ""
X = 0

DO WHILE X < (METPCT * 70)
 DOTSTRING = DOTSTRING+"."
 X = X+1
ENDDO
@ R+18, C SAY DOTSTRING
*************************************************************
*************************************************************
PROCEDURE PONDSTAT
*************************************************************
* Writes updated values for pond vol, loss by evap and SURFVOL after any
* change in volume caused by evaporation or infiltration
@ 12,  17  SAY SURFVOL  PICTURE "#####.#"
@ 17,  39  SAY NEWPOND  PICTURE "########"
@ 18,  39  SAY PONDLOSS PICTURE "######.#"
*************************************************************
*************************************************************
PROCEDURE GRIDSTAT
*************************************************************
* Updates screen with current values for GRID element variables
* Done once for each grid element for each pass through the GRID

PRES_TIME = TIME()
@ 9,   17  SAY SD0 PICTURE "####"
@ 10,  17  SAY FLOODVOL PICTURE "#######"
@ 11,  17  SAY MAXDEPTH PICTURE "#####.#"
@ 12,  17  SAY RETAINED PICTURE "#####.#"
@ 17,  67  SAY LTRIM(PRES_TIME)
*************************************************************
```

```
**************************************************************
PROCEDURE READS1
**************************************************************
* Reads in from the SOILDAT file the values for the soil variables for
* Store1 for the soil indentified to ocurr at this grid cell site

MS1THETA  = S1THETA
MP        = C->P
MA        = C->A
MK1SAT    = C->FC1
MS1SAT    = C->VOLTP1
MGWC1     = C->GWC1
MS1MIN    = C->VOLFP1
MS1WP     = C->VOLWP1
S1ROOM    = MS1SAT - MS1THETA
**************************************************************
**************************************************************
PROCEDURE S1STAT
**************************************************************
* Updates screen with current values for Store1 Soil moisture variables

@ 8, 40  SAY MS1SAT   PICTURE "####.#"
@ 9, 40  SAY MS1MIN   PICTURE "####.#"
@10, 40  SAY INI1     PICTURE "####.#"
@11, 40  SAY S1ROOM   PICTURE "####.#"
@12, 40  SAY DR1      PICTURE "##.###"
@13, 40  SAY S1DELTA  PICTURE "####.#"
@14, 40  SAY ACTINFT  PICTURE "####.#"
@14, 60  SAY EVAPVOL  PICTURE "###.##"
**************************************************************
**************************************************************
PROCEDURE S2STAT
**************************************************************
* Writes updated values of the Store2 soil hydraulic variables to screen
@ 8, 50  SAY MS2SAT   PICTURE "####.#"
@ 9, 50  SAY MS2MIN   PICTURE "####.#"
@10, 50  SAY INI2     PICTURE "####.#"
@11, 50  SAY S2ROOM   PICTURE "####.#"
@12, 50  SAY DR2      PICTURE "##.###"
@13, 50  SAY S2DELTA  PICTURE "####.#"
**************************************************************
**************************************************************
PROCEDURE S3STAT
**************************************************************
* Writes updated values of the Store3 soil hydraulic variables to screen
@ 8, 60  SAY MS3SAT   PICTURE "####.#"
@ 9, 60  SAY MS3MIN   PICTURE "####.#"
@10, 60  SAY INI3     PICTURE "####.#"
@11, 60  SAY S3ROOM   PICTURE "####.#"
@12, 60  SAY DR3      PICTURE "##.###"
@13, 60  SAY S3DELTA  PICTURE "####.#"
**************************************************************
```

Table A11.1 Structure and content of SETUP database file

No.	Field Name	Type	Width	Dec	Field Description
1	RUNUM	Numeric	2		User assigned number identifies run
2	GRIDFILE	Character	8		Name of file containing grid data
3	SOILFILE	Character	8		Name of file containing soil data
4	METFILE	Character	8		Name of file containing met data
5	PONDFILE	Character	8		Name of file containing pond data
6	FLOWFILE	Character	8		Name for output file for runoff stats
7	TIMESTEP	Numeric	2		User assigned time step in hours
8	ENDAT	Numeric	3		Julian day number to stop program at
9	PATH	Character	10		DOS subdirectory for output data
10	EVAPTYPE	Character	8		User choice of evaporation eqn to use
11	TOPSNOWT	Numeric	5	1	Temperature at snow surface on day 1
12	BOTSNOWT	Numeric	5	1	Temperature at soil surface on day 1
13	SNOWTEMP	Numeric	5	1	Starting temperature of snow on day1
14	SNOWDENS	Numeric	3		User assigned initial snow density
15	MAXSNOW	Numeric	2		Number of reference snow depths
16	ALBSOIL	Numeric	4	2	User assigned max albedo for soil
17	ALBSNOW	Numeric	4	2	User assigned max albedo for snow
18	LAI	Numeric	3	1	Leaf Area Index used for evap model
19	GAMMA	Numeric	7	5	Psychromatric constant for evap eqns
20	PTCONST	Numeric	4	2	Priestly-Taylor evap eqn α constant
21	COFNGA	Numeric	4	2	Coefficient A for Monteith evap eqn
22	COFNGB	Numeric	4	1	Coefficient B for Monteith evap eqn
23	EWETLO	Numeric	3	1	Constant in Monteith evap eqn (0.7)
24	EWETHI	Numeric	3	1	Constant in Monteith evap eqn (1.1)
25	RSMIN	Numeric	4	1	Monteith minimum canopy resistance
26	RSMAX	Numeric	5	1	Monteith maximum canopy resistance
27	K4SAT	Numeric	15	13	Saturated zone hydraulic conductivity
28	RTYPE	Numeric	1		Tells if radiation input is net or global

Table A11.2 Structure and content of METDATA database file

No.	Field Name	Type	Width	Dec	Field Description
1	MONTH	Character	6		Current month in characters
2	DAY	Numeric	3		Current day in the month (1-31)
3	JULIAN	Numeric	3		Number of Julian day in year
4	HOUR	Numeric	2		Hour of the day (1-24)
5	PREC	Numeric	5	2	Total precipitation (mm) in last hour
6	RADIA	Numeric	7	2	Mean hr global radiation flux (Wm^{-2})
7	TEMP	Numeric	5	1	Mean hourly air temperature (°C)
8	RH	Numeric	5	2	Mean hourly relative humidity (fract)
9	WIND	Numeric	5	2	Mean hourly wind speed (m sec^{-2})
10	CLOUD	Numeric	4	2	Mean hourly cloud cover (percent)
11	MAXRAD	Numeric	7	2	Maximum radiation expected for hour
12	DEGCLD	Numeric	4	2	Mean hourly cloud cover (fraction)
13	SOILT1	Numeric	5	1	Soil temperature (°C) at 0-15 cm.
14	SOILT2	Numeric	5	1	Soil temperature (°C) at 15-40 cm.
15	SOILT3	Numeric	5	1	Soil temperature (°C) at 40-60 cm.
16	ALBEDO	Numeric	4	2	Snow model estimate surface albedo.
17	PENMAN	Numeric	5	3	Penman estimated evaporation (mm)
18	MONTEITH	Numeric	5	3	Monteith estimated evaporation (mm)
19	PRIESTLY	Numeric	5	3	Priestley estimated evaporation (mm)
20	MAKKINK	Numeric	5	3	Makkink estimated evaporation (mm)
21	RITCHIE	Numeric	5	3	Ritchie estimated evaporation (mm)
22	QS	Numeric	8	2	Absorbed short wave radiation Wm^{-2}
23	QA	Numeric	8	2	Atmos long wave radiation Wm^{-2}
24	QE	Numeric	8	2	Emitted long wave radiation Wm^{-2}
25	QH	Numeric	8	2	Sensible heat transfer Wm^{-2}
26	QV	Numeric	8	2	Latent heat transfer Wm^{-2}
27	SUMAE	Numeric	8	2	Sum of $Q_a + Q_e$ in snowmelt model
28	DELTAG	Numeric	7	2	Change in heat storage snowmelt eqn
29	SNOWT	Numeric	6	2	Calculated snow temp snowmelt eqn
30	MELTVOL	Numeric	6	2	Volume of snow melted in time step
31	WATEQV	Numeric	7	2	Water equivalent of snow
32	SNOWDEP	Numeric	5	2	Depth of snow at this time step

continued.....

Table A11.2 Structure and content of METDATA database file (continued)

No.	Field Name	Type	Width	Dec	Field Description
33	SMELT	Logical	1		True or False for melting conditions
34	MV5	Numeric	6	2	Melt volume if initial depth is 5 cm
35	MV10	Numeric	6	2	Melt volume if initial depth is 10 cm
36	MV15	Numeric	6	2	Melt volume if initial depth is 15 cm
37	MV20	Numeric	6	2	Melt volume if initial depth is 20 cm
38	MV30	Numeric	6	2	Melt volume if initial depth is 30 cm
39	MV40	Numeric	6	2	Melt volume if initial depth is 40 cm
40	MV50	Numeric	6	2	Melt volume if initial depth is 50 cm
41	MV60	Numeric	6	2	Melt volume if initial depth is 60 cm
42	MV70	Numeric	6	2	Melt volume if initial depth is 70 cm
43	MV80	Numeric	6	2	Melt volume if initial depth is 80 cm
44	MV90	Numeric	6	2	Melt volume if initial depth is 90 cm
45	MV100	Numeric	6	2	Melt volume if initial depth is 100 cm
46	MV125	Numeric	6	2	Melt volume if initial depth is 125 cm
47	MV150	Numeric	6	2	Melt volume if initial depth is 150 cm
48	MV175	Numeric	6	2	Melt volume if initial depth is 175 cm
49	MV200	Numeric	6	2	Melt volume if initial depth is 200 cm
50	OUT	Numeric	1		User assigned code to request output

Table A11.3 Structure and content of GRIDDATA database file

No.	Field Name	Type	Width	Dec	Field Description
1	ROW	Numeric	3		Grid row for given cell
2	COL	Numeric	3		Grid column for given cell
3	ELEV	Numeric	5	1	DEM elevation for given cell
4	DDIR	Numeric	1		Coded drainage direction for cell
5	DREC	Numeric	5		dB Record No. of cell this drains to
6	SHEDNO	Numeric	3		Number of watershed cell belongs to
7	UPSLOPE	Numeric	5		Number of cells upslope of this cell
8	SHEDORD	Numeric	3		Order in which to process this shed
9	SHEDNOW	Numeric	3		Used to group sheds for PONDMAP
10	FLODVOL	Numeric	7	2	Pond volume at which cell first floods
11	PAREA	Numeric	5		Unit area of pond when it first floods
12	PONDELEV	Numeric	5	1	Current elevation of ponding (m)
13	PONDEP	Numeric	6	3	Current depth of ponding at cell (m)
14	POND	Logical	1		True/False, indicates if cell is flooded
15	SURFH20	Numeric	8	1	Vol. of water (mm) in surface store
16	MAXDEP	Numeric	3		Max depth of water (mm) on surface
17	SNOWDEP0	Numeric	4		Depth of snow pack at cell on day 1
18	S1THETA	Numeric	5	1	Total vol water (mm) in S1 Soil Store
19	S2THETA	Numeric	5	1	Total vol water (mm) in S2 Soil Store
20	S3THETA	Numeric	5	1	Total vol water (mm) in S3 Soil Store
21	SOIL	Numeric	2		Code to identify soil series at grid cell

Table A11.4 Structure and content of SOILDATA database file

No.	Field Name	Type	Width	Dec	Field Description
1	SOIL	Numeric	2		User assigned code number for soil
2	BD1	Numeric	4	2	Bulk density of the A horizon
3	PD1	Numeric	4	2	Particle density used for A horizon
4	MINPER1	Numeric	3		Minimum permeability of A horizon
5	MAXPER1	Numeric	3		Maximum permeability of A horizon
6	FC1	Numeric	3		Final S1 infiltration capacity (mm/hr)
7	TP1	Numeric	2		Total Porosity (%) of the A horizon
8	FP1	Numeric	2		Field capacity (%) of the A horizon
9	WP1	Numeric	2		Wilting point (%) of the A horizon
10	DEPTH1	Numeric	3		Thickness (cm) of the A horizon
11	VOLTP1	Numeric	3		Vol. of water in S1 at total saturation
12	VOLFP1	Numeric	3		Vol. of water in S1 at field capacity
13	VOLWP1	Numeric	3		Vol. of water in S1 at wilting point
14	GWC1	Numeric	3		Gravitational water capacity of S1
15	BD2	Numeric	4	2	Bulk density of B horizon (S2)
16	PD2	Numeric	4	2	Particle density used for B horizon
17	MINPER2	Numeric	3		Minimum permeability of B horizon
18	MAXPER2	Numeric	3		Maximum permeability of B horizon
19	FC2	Numeric	3		Final S2 infiltration capacity (mm/hr)
20	TP2	Numeric	2		Total Porosity (%) of the B horizon
21	FP2	Numeric	2		Field capacity (%) of the B horizon
22	DEPTH2	Numeric	3		Thickness (cm) of the B horizon
23	VOLTP2	Numeric	3		Vol. of water in S2 at total saturation
24	VOLFP2	Numeric	3		Vol. of water in S2 at field capacity
25	GWC2	Numeric	3		Gravitational water capacity of S2
26	BD3	Numeric	4	2	Bulk density of C horizon (S3)
27	PD3	Numeric	4	2	Particle density used for C horizon
28	MINPER3	Numeric	3		Minimum permeability of C horizon
29	MAXPER3	Numeric	3		Maximum permeability of C horizon
30	FC3	Numeric	3		Final S3 infiltration capacity (mm/hr)
31	TP3	Numeric	2		Total Porosity (%) of the C horizon
32	FP3	Numeric	2		Field capacity (%) of the C horizon

continued....

Table A11.4 Structure and content of SOILDATA database file (continued)

No.	Field Name	Type	Width	Dec	Field Description
33	DEPTH3	Numeric	3		Thickness (cm) of the C horizon
34	VOLTP3	Numeric	3		Vol. of water in S3 at total saturation
35	VOLFP3	Numeric	3		Vol. of water in S3 at field capacity
36	GWC3	Numeric	3		Gravitational water capacity of S3
37	P	Numeric	4	2	ANSWERS drainage coefficient
38	A	Numeric	4	1	ANSWERS infiltration coefficient
39	RC	Numeric	4	2	ANSWERS roughness coefficient
40	HU1	Numeric	3		ANSWERS maximum roughness

Table A11.5 Structure and content of PONDDATA database file

No.	Field Name	Type	Width	Dec	Field Description
1	SHEDNO	Numeric	3		Unque number assigned to watershed
2	SHEDAREA	Numeric	5		Area of the watershed in grid units
3	PITROW	Numeric	3	4	Row location of the pit centre cell
	PITCOL	Numeric	3		Column location of the pit centre cell
5	PITELEV	Numeric	5	1	DEM elevation of the pit centre cell
6	PITVOL	Numeric	8	3	Computed pit volme in m * grid units
7	PITAREA	Numeric	4		Surface area of the pond in grid units
8	DRAINSTO	Numeric	3		ID number of watershed for overspill
9	OUTROW	Numeric	3		Grid row in this shed for overspill
10	OUTCOL	Numeric	3		Grid column in this shed for overspill
11	OUTELEV	Numeric	5	1	Elevation of overspill cell in this shed
12	OVERROW	Numeric	3		Grid row in neighbor for overspill
13	OVERCOL	Numeric	3		Grid column in neighbor for overspill
14	OVERELEV	Numeric	5	1	Elavation of overspill cell in neighbor
15	POURELEV	Numeric	5	1	Higher of OUTELEV or OVERELEV
16	VARATIO	Numeric	5	1	Volume to area ratio (mm to fill pond)
17	VOLINPIT	Numeric	8	3	Volume of water presently in pond
18	VOLTOFLOOD	Numeric	8	3	Volume of water required to fill pond
19	NEXTPIT	Numeric	3		ID number of 2^{nd} choice for overspill
20	PITUP	Numeric	3		ID number of any overlying pit
21	PREVOL	Numeric	8	3	Volume of all ponds filled before this
22	TOTALVOL	Numeric	8	3	Volume of this & all ponds below it.
23	POUREC	Numeric	6		dB Record number of overspill cell
24	PITREC	Numeric	6		dB Record number of pit cell
25	TOPREC	Numeric	6		dB Record no. of highest cell in shed
26	FULL	Logical	1		True/False indicates if pond is full
27	FINAL	Logical	1		True/False indicates if drains to edge
28	ORDER	Numeric	3		Order in which to process shed
29	VISITED	Logical	1		True/False indicates if pointer used
30	ROW2	Numeric	3		Grid row of 2^{nd} choice pour cell
31	COL2	Numeric	3		Grid column of 2^{nd} choice pour cell
32	POUREC2	Numeric	6		dB record No. of 2^{nd} choice pour cell